Turbulence Measurement of the Planetery Boundary Layer from a 213m Meteorological Tower

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(Manuscript received September 18, 1985)

Abstract

The results of turbulence measurement on the 213 m meteorological tower using sonic anemometer-thermometers, thermocopule psychrometers, Lyman-alpha hygrometers and an infrared hygrometer are reported. The main part of the obseravtion was continued for 23 hours and the time variations of statistics of turbulence in the planetary boundary layer are analysed.

Heat balance at the ground surface during a day is studied assuming the ground heat flux as a residual of heat balance equation. Budget equations of turbulent kinetic energy, temperature variance, humidity variance and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ are also investigated in the diurnally varying planetary boundary layer below 200 m.

1. Introduction

Turbulence measurements in the planetary boundary layer are scarse when compared to those in the atmospheric surface layer, due to the difficulties in the observation platform. Most of the turbulence measurements in the planetary boundary layer were made on an aircraft or a captive balloon. However they are made on moving platforms, troublesome correction for motion of the platform is required. Furthermore, continuous measurement at a certain level for a long period is not easy.

Recently, meteorological towers for planetary boundary layer observation (e.g. Boulder Atmospheric Observatory (Kaimal and Gaynor[1]) have been constructed at a few sites in the world. One of the high meteorological towers with the height of 213 m was constructed at the Meteorological Research Institute in Tsukuba, about 60 km north-east of Tokyo in the center of the Kanto plain (Hanafusa *et al.*[2]). The basic meteorological parameters in the planetary boundary layer below 213 m are recorded continuously by the Meteorological Research Institute.

The present author and his collaborators made an intensified observation of the atmospheric turbulence on this tower in 1983. The detailed analysis of the turbulent transfer processes of heat and water vapor are reported in another paper (Tsukamoto[3]). The results of analysis of the heat balance at the ground surface and budgets of turbulent kinetic energy, variances of temperature and humidity, and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ in the planetary boundary layer are shown in the present paper.

2. Observation

Intensive observation was conducted for 5 days as shown in **Fig. 1.** The main part of the observation is Run 3031, that started in the evening of 30 Oct. and continued for 23 hours. The diurnal variation of the planetary boundary layer can be studied from the data of this run including the moisture structure. Development of the convective mixed layer is a most interesting phenomenon in the diurnally changing planetary boundary layer and it was observed again in the morning of 7 Dec. in Run 1207, without humidity measurement. Run 281-Run 322 were for the study of the transfer processes of heat and water vapor in the lowest 100 m layer.

Turbulent fluctuations of the three components of wind veloicty and temperature were measured with three dimensional sonic anemometer-thermometers (Kaijo Denki, DAT–300) installed on the tower at 200, 150, 100, 50, 25 and 10 m levels. Wet- and dry-bulb temperatures were measured with fine wire thermocouple psychrometers (Kaijo Denki, PY–100) attached to the probes of the sonic anemometers. However, a large amount of errors are seen in the high frequency part of the synthesized specific humidity fluctuations from psychrometer data in the lower layer because of its slow response character (Tsukamoto[4]). Therefore, humidity fluctuations were measured with quick response hygrometers, Lyman-alpha hygrometers (Electromagnetic Research corp., Model BLR) at 100, 50 and 25 m and an infrared hygrometer (Kaijo Denki, AH–100) at 10 m. However, the absolute amplitude of the fluctuations of these quick response hygrometers were calibrated by the thermocouple psychrometer at the same level in the low frequency region because sensitivity of these quick response hygrometers is not stable enough.

All of the signals from the turbulence sensors were send to the A-D converter with sampling frequency of 10Hz and the digitized data were stored on magnetic tapes with mini-computer system (HITAC–20E). The block diagram of the observation is shown in **Fig. 2.**

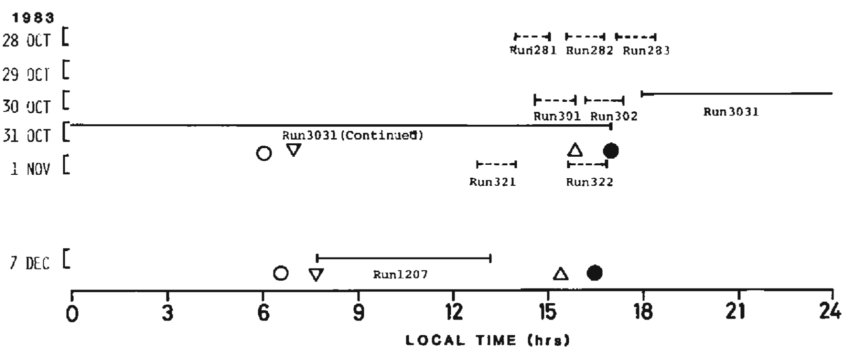

Fig. 1 Duration of the runs during the observation. Solid lines represent the measurements at 6 levels (200, 150, 100, 50, 25, 10 m) and dashed lines are at 3 levels (100, 50, 25 m). Open and closed circles are times of the sunrise and sunset respectively, and downward and upward triangles are times of change in sign of net radiation.

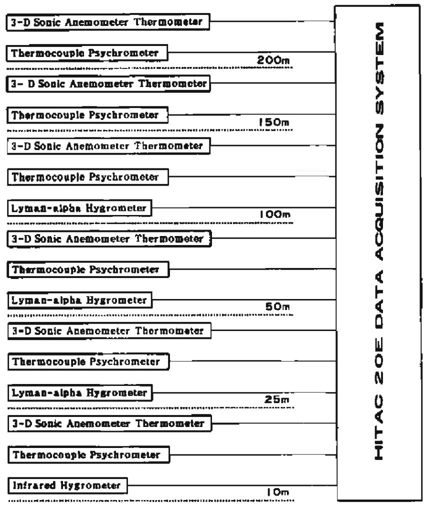

Fig. 2 Block diagram of the observation

The records are intermittently discontinuous because of adjustments of zero shift and gain of the amplifiers. The time of intermission was reduced to less than 3 minutes and sampling duration and averaging time were selected as 30 minutes and 0.4 sec, respectively. It was almost fair weather except a decrement of solar radiation around noon on 31st Oct. Mean wind speed was less than 5 m/s except in the midnight from 30 to 31 Oct. The basic data set of the observation is tabulated in the Appendix.

3. Heat balance

The 3 hourly integrated values of the terms in the heat balance equation at the ground surface in Run 3031 are shown in **Table 1.** The heat balance equation is expressed as follows.

$$Q_N = Q_H + Q_E + Q_G, \qquad (1)$$

where Q_N is the net radiation, Q_H and Q_E are turbulent fluxes of sensible heat

Table 1 3 hourly integrated values of the components in the heat balance equation at the surface in MJ/m². The integrated values during the daytime (9 hours), nighttime (14 hours) and 23 hours are also included.

TIME / COMP	8h–11h	11h–14h	14h–17h	8h–17h daytime	18h–8h nighttime	18h–17h 23hours
Q_N	2.13	1.84	0.03	4.00	−2.10	1.90
Q_H	0.91	0.93	0.09	1.93	−0.30	1.63
Q_E	0.86	0.94	0.27	2.07	0.25	2.32
Q_G	0.36	−0.03	−0.33	0.00	−2.15	−2.15

and latent heat into the atmosphere measured at the height of 25 m, and Q_G is the heat flux into the ground. Positive values in Q_N and Q_G mean downward flux and vice versa in Q_H and Q_E. The values of Q_N were kindly offered by Teteno Aerological Observatory as also tabulated in the Appendix. Ground heat flux, Q_G, was not measured in the present observation but it was estimated as the residual of Eq. (1).

In the morning and around noon upward turbulent fluxes of sensible heat and latent heat show almost the same values, and in the evening, sensible heat flux disappeared quickly but latent heat flux remained upward. Ground heat flux, Q_G, was downward in the morning due to excess of incoming radiation and turned to upward in the evening due to remaining upward latent heat flux. As a dyatime mean (8:00–17:00), the incoming radiation almost balances with turbulent fluxes of sensible heat and latent heat, and the ground heat flux is negligibly small. The daytime mean values of sensible heat flux and latent heat flux near the surface was about 60 W/m^2 and 64 W/m^2 respectively. The value of latent heat flux corresponds to 2.3 mm/day of evaporation. On the other hand, during the nighttime, latent and sensible heat fluxes are negligibly small and the net radiation balances with the upward ground heat flux. The values throughout the day show that the averaged ground heat flux is upward showing heat loss of 2.15 MJ/m^2 for 23 hours. As the observation was made in the end of October, the ground was cooling gradually.

Diurnal change of the heat flux shows distorted sinusoidal form having its minimum in the early morning and maximum around noon. To describe such diurnal changes in functional form, harmonic analysis is often applied with diurnal and semi-diurnal terms. However it is physically meaningless to include the semi-diurnal term to express skewness of the diurnal variation properly. Azuma[5] has proposed another expression for the diurnal variation of air temperature with four parameters. That is,

$$F=F_0+A\sin(\omega t-\gamma\sin(\omega t+\varepsilon)) \quad \cdots\cdots (2)$$

where F_0 is mean value, A is amplitude, $\omega=2\pi/D$, D being 24 hours, and γ and ε are parameters. The parameters fitted the diurnal changes of heat and water vapor fluxes during the day and are computed as shown in **Table 2.**

The maximum values of sensible heat and water vapor fluxes occur around noon but that of sensible heat flux is a little earlier than noon and that of water vapor flux is a little later than noon. The variations of time of maximum with height are not so clear for both of them. The mean values of sensible heat flux, F_0 decreases with height from 67.5 W/m^2 at 10 m to 28.7 W/m^2 at 200 m, but that of water vapor flux decreases little throughout the layer. The amplitude of diurnal change of heat flux, A also decreases with height to about a half within the 200 m layer but that of water vapor flux does not change with height.

It can be said that the divergence of mean sensible heat flux, F_0 is consumed to maintain the mean temperature of the air layer against radiative cooling. That is about 0.2 W/m^3. While the vertical divergence of amplitude of sensible heat flux, A is consumed for the diurnal changes of air temperature in the layer. The integrated divergence of sensible heat flux during the daytime (9 hours) is 0.006 MJ/m^3 and this

Table 2 The values of the parameters and times of maximum values in the formula by Azuma[5] for the sensible heat flux and the water vapor flux.

PARAMETER	200 m	150 m	100 m	50 m	25 m	10 m
〈Sensible heat flux〉						
F_0 (W/m^2)	28.7	49.9	52.1	49.7	60.5	67.5
A (W/m^2)	40.4	58.9	80.2	79.8	88.0	92.2
ε (rad)	−0.80	−1.61	1.01	−0.93	−1.06	−0.99
γ (rad)	1.66	1.29	1.27	1.13	1.18	1.21
max time	11:10	12:20	11:25	11:05	11:20	11:15
〈Water Vapor Flux〉						
F_0 ($g/m^2/s$)	0.0234	0.0229	0.0242	0.0192	0.0267	0.0146
A ($g/m^2/s$)	0.0360	0.0356	0.0439	0.0285	0.0301	0.0146
ε (rad)	−1.20	−1.54	−1.26	−1.92	−1.65	−1.63
γ (rad)	0.80	0.79	0.73	1.30	1.13	1.15
max time	11:40	12:05	11:40	12:50	12:20	12:00

is roughly equivalent to the amplitude of diurnal air temperature change.

On the other hand, water vapor flux distribution shows only a little difference with height resulting in small water vapor flux divergence. However, specific humidity increased very slowly throughout the day as shown in **Fig. 3.** The rate of increase is about 0.11 $g/m^3/hr$ in the whole layer. When the depth of planetary

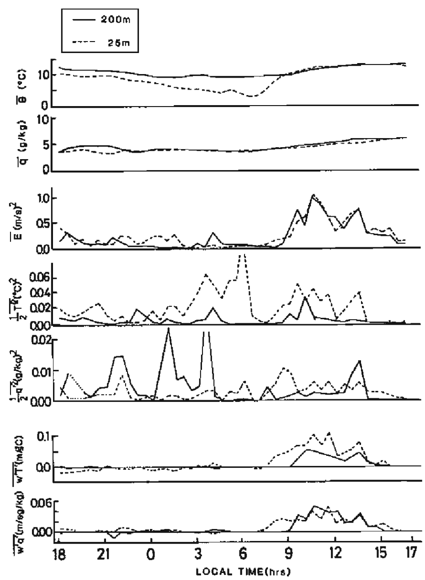

Fig. 3 Diurnal variations of potential temperature, specific humidity, turbulent kinetic energy, temperature variance, humidity variance and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ during Run 3031. Solid lines show the 200 m level and dashed lines show the 25 m level.

boundary layer is assumed to be 1000 m, this value corresponds to a water supply of 120 g/m^2/hr from the boundary and this means 2.9 mm/day of evaporation from the surface. This value is roughly equivalent to the observed water vapor flux from the ground. This might show that water vapor is gradually stored in the air layer without distinct diurnal changes such as temperature.

3. Turbulence budget equations in the planetary boundary layer

Budgets of turbulent kinetic energy, temperature variance and specific humidity variance are expressed as follows, assuming horizontal homogeneity and zero mean vertical velocity (Lenschow, Wyngaard and Pennell[6]).

$$\frac{\partial \overline{E}}{\partial t} = -\overline{u'w'}\frac{\partial U}{\partial z} + \frac{g}{\theta}\overline{w'T'} - \frac{\partial \overline{w'E}}{\partial z} - \frac{1}{\rho}\frac{\partial \overline{w'p'}}{\partial z} - \varepsilon \quad \cdots\cdots\cdots\cdots (3)$$

$$\frac{1}{2}\frac{\partial \overline{T'^2}}{\partial t} = -\overline{w'T'}\frac{\partial \theta}{\partial z} - \frac{1}{2}\frac{\partial \overline{w'T'^2}}{\partial z} - N_\theta \quad \cdots\cdots\cdots\cdots (4)$$

$$\frac{1}{2}\frac{\partial \overline{q'^2}}{\partial t} = -\overline{w'q'}\frac{\partial q}{\partial z} - \frac{1}{2}\frac{\partial \overline{w'q'^2}}{\partial z} - N_q \quad \cdots\cdots\cdots\cdots (5)$$

(a) (b) (c) (d) (e) (f)

where terms (a)-(f) are;

(a): local time change of turbulent kinetic energy, $E=1/2(\overline{u'^2+v'^2+w'^2})$, temperature variance, $1/2\overline{T'^2}$ and humidity variance, $1/2\overline{q'^2}$.

(b): production term by the interaction of vertical flux and vertical mean gradient, which is called shear production or gradient production.

(c): production term by buoyancy, called buoyant production.

(d): divergence of the turbulent fluxes of E, $1/2T'^2$, $1/2q'^2$, called turbulent transport.

(e): transfer of energy due to pressure fluctuation, called pressure transport.

(f): rate of destruction of fluctuations due to molecular viscosity or diffusivity, called dissipation rate.

Budgets of turbulent fluxes of temperature and humidity can be expressed as follows (Lenschow, Wyngaard and Pennell[6]).

$$\frac{\partial \overline{w'T'}}{\partial t} = -\overline{w'^2}\frac{\partial \theta}{\partial z} + \frac{g}{\theta}\overline{T'^2} - \frac{\partial \overline{w'^2T'}}{\partial z} - \overline{T'\frac{\partial p'}{\partial z}} \quad \cdots\cdots\cdots\cdots (6)$$

$$\frac{\partial \overline{w'q'}}{\partial t} = -\overline{w'^2}\frac{\partial q}{\partial z} + \frac{g}{\theta}\overline{T'q'} - \frac{\partial \overline{w'^2q'}}{\partial z} - \overline{q'\frac{\partial p'}{\partial z}} \quad \cdots\cdots\cdots\cdots (7)$$

(a) (b) (c) (d) (e)

(a)-(e) have almost similar meanings as Eqs. (3)–(5).

Experimental study of these equations in the surface boundary layer have been carried out by many authors especially in the turbulent kinetic energy budget equation. Synthetic studies of turbulence budget equations in the surface boundary layer were reported by Wyngaard and Coté[7] and Wyngaard, Coté and Izumi[8] based on the Kansas experiment data. They found that terms of the budget equations were well expressed with Monin-Obukhov similarity in the surface boundary layer and the relative importance of pressure terms were evaluated. Turbulent kinetic energy budget in the convective planetary boundary layer was studied by Caughey and Wyngaard[9] with the mixed layer similarity based on the Minnesota experiment data of tethered balloon. Lenschow, Wyngard and Pennell[6] have studied all of the budget equations (3)–(7) with the AMTEX aircraft data. They found that over most of the mixed layer over the ocean, the temperature variance was maintained by turbulent transport and the temperature flux by buoyant production. While, in contrast, the humidity variance and flux were maintained primairly by gradient production. Recently, budgets of turbulent kinetic energy, temperature variance and temperature flux over the ground were studied by Zhou *et al.*[10] based on the BAO tower data[1]. In the case where the depth of the mixed layer was below the top of the 300 m tower and in nearly stationary state for several hours, they found that terms in the kinetic energy budget equation were similar to previous studies in the mixed layer. Above the mixed layer, shear production becomes large and is approximately balanced by the sum of buoyancy, dissipation and transport terms. The temperature variance and flux budgets also have large terms and significant residuals in the overlying inversion.

In the present study, all of the the terms in the budget equations (3)–(7) are evaluated except the pressure terms, (e) for the layers between two adjacent levels. The values of the dissipation rates of turbulent kinetic energy, ε temperature variance, N_θ and humidity variance, N_q are determined from the power spectral densities of horizontal wind speed, $S_u(n)$ temperature, $S_T(n)$ and specific humidity, $S_q(n)$ by the following relations, assuming Kolmogoroff hypothesis in the inertial subranges.

$$\varepsilon=\left(\frac{n\,S_u(n)}{\alpha}\right)^{2/3}\frac{2\pi n}{U}, \qquad (8)$$

$$N_\theta=\frac{n\,S_T(n)}{\beta_T}\left(\frac{n\,S_u(n)}{\alpha}\right)^{1/2}\frac{2\pi n}{U}, \qquad (9)$$

$$N_q=\frac{n\,S_q(n)}{\beta_q}\left(\frac{n\,S_u(n)}{\alpha}\right)^{1/2}\frac{2\pi n}{U}, \qquad (10)$$

where n is the frequency in Hz, U is the mean wind speed. α, β_T, β_q are Kolmogoroff constants and their values are selected as $\alpha=0.5$, $\beta_T=0.82$ (Kaimal *et al.*[11]) and $\beta_q=0.76$ (Dyer and Hicks[12]).

Time variations of the turbulent kinetic energy, temperature variance, humidity variance and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ during the Run 3031 are plotted in **Fig. 3** for the heights of 200 m and 25 m. Diurnal variations are clearly seen in the turbulent kinetic energy and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$, but they are not clear in the variances of temperature and humidity. **Fig. 4** shows the mean profiles of turbulent kinetic energy, temperature variance, humidity variance and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ in the daytime (10:00–13:00) and in the nighttime (21:00–24:00). Vertical distribution of turbulent kinetic energy is almost constant with height throughout the run but the magnitude is different in the daytime and the nighttime. Vertical profiles of temperature variance and humidity variance are different from turbulent kinetic energy. They gradually decrease with height in the

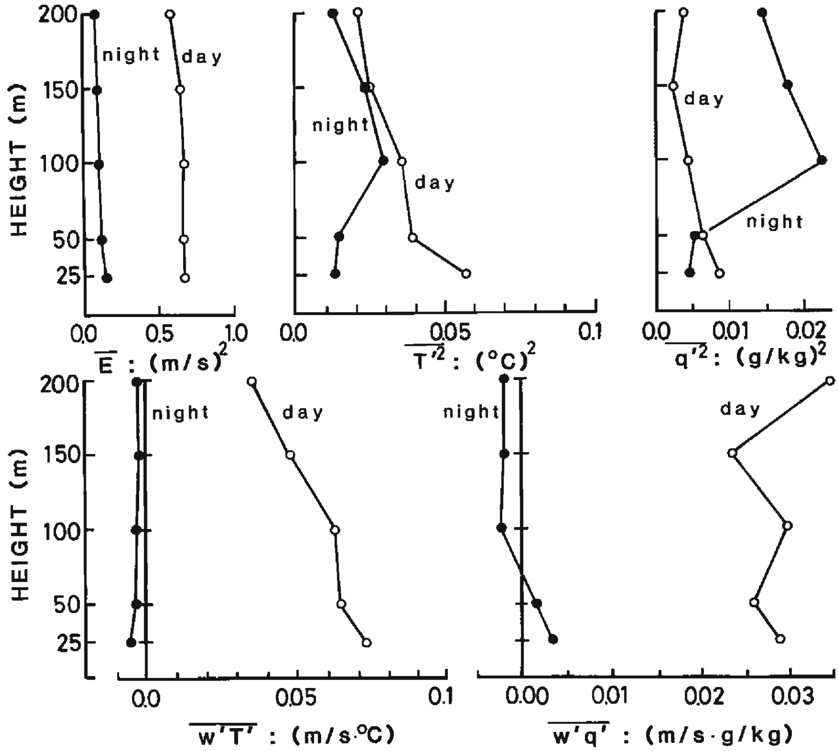

Fig. 4 Mean vertical profiles of turbulent kinetic energy, $\overline{E}$ temperature variance, $\overline{T'^2}$, humidity variance, $\overline{q'^2}$ and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ for the daytime (10:00–13:00) and the nighttime (21:00–24:00) during Run 3031.

daytime, and in the nighttime, the values in the lower layer decrease with decreasing height and the promiennt peaks are seen around the height of 100 m. Large values of humidity variance is seen in the upper part of the layer in the nighttime. Turbulent flux, $\overline{w'T'}$ decreases with height in the daytime but $\overline{w'q'}$ is almost constant with height in the daytime. They are almost zero in the nighttime.

3.1 Turbulent kinetic energy budget

Fig. 5 shows the diurnal variations of the terms of turbulent kinetic energy budget equation during Run 3031 in the layers of 200–150 m and 50–25 m. During the nighttime, relatively high wind speed was observed until 3:00 JST and large values of shear production are seen in the lower layer. It roughly balances with viscous dissipation. While in the upper layer, all of the terms are observed to be small values at the nighttime. And in the morning, the increase of buoyant production is seen in the lower layer and a little later it occurrs in the upper layer also. In the lower layer, shear production contributes as another important energy source throughout the run. In the morning, increase of buoyant production comes earlier than that of shear production in the lower layer. The same condition is also found in the Run 1207. That is, the turbulence is created by buoyancy at first in the morning

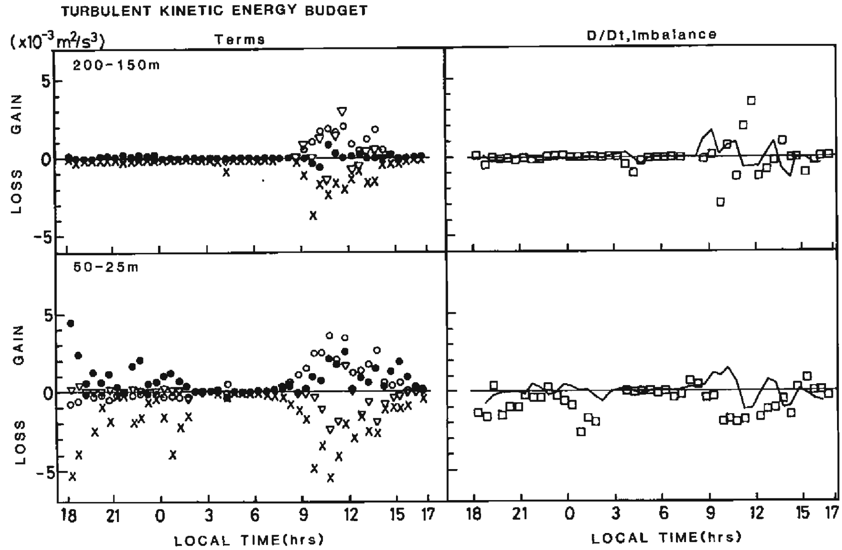

Fig. 5 Diurnal variations of the terms in the turbulent kinetic energy budget equations for the layers of 200–150m and 50–25m. Closed circles are shear production, open circles are buoyant production, triangles are turbulent transport and crosses are dissipation rate. The right half of the figure represents the local time change of turbulent kinetic energy multiplied by 10 with solid lines and the imbalance with squares. The imbalance is defined as (right hand side)-(left hand side) of Eq. (3) except the pressure transport term.

and then a large amount of momentum is transferred from the upper level. Viscous dissipation also increases with production terms in the morning and decreases with them in the evening. The values of local time change of turbulent kinetic energy

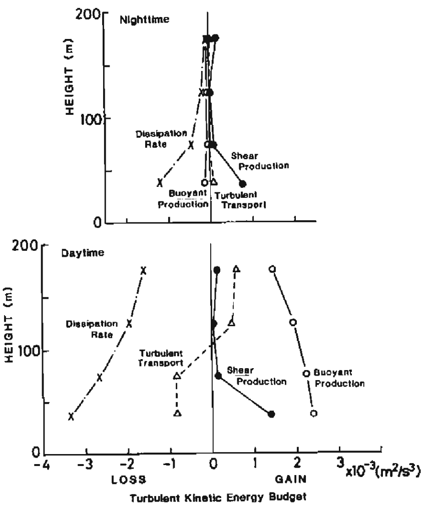

Fig. 6 Mean vertical profiles of the terms in the turbulent kinetic energy budget equation for the nighttime (21:00–24:00) and the daytime (10:00–13:00).

determined from **Fig. 3** are shown in the right half of **Fig. 5** with the imbalance of Eq. (3). The local time change is small and it is plotted as the values multiplied by 10 to the raw data. The "imbalance" is defined as the (right hand side)-(left hand side) in Eq. (3) and include the pressure term. Positive value means excess of turbulent kinetic energy in Eq. (3). In the daytime, negative imbalance is seen especially in the lower layer. During this experiment, pressure transport was evaluated in Runs 281–322, by trial, using multi-level observations of static-pressure fluctuations below 100 m by the new static-pressure probe (Mitsuta, Tsukamoto and Kataoka[13]). The results show that this term is energy loss in most cases and the term even contribute to increase the imbalance.

A part of the study of the turbulent kinetic energy budget equation with the present data has been reported by Yamamoto and Tsukamoto[14]. They found that the Monin-Obukhov similarity is not effective in the layer above 50 m. Mean vertical profiles of the terms in the turbulent kinetic energy budget equation are shown in **Fig. 6** for the nighttime and the daytime. It is concluded that dominant production terms are buoyant production term in the daytime and shear production term in the strong wind or nighttime case. In the unstable condition, the turbulent transport term shows energy loss in the lower layer and gradually changes to energy gain in the upper layer.

3.2 Variance budgets of temperature and humidity

The diurnal variations of temperature vairance and specific humidity variance are not so prominent as turbulent kinetic energy, and time variations of variances in the nighttime are as large as that in the daytime, which is shown in **Fig. 3.** The diurnal variations of the terms in the variance budget equations are shown in **Figs. 7 and 8.** In contrast to the turbulent kinetic energy budget, the source of variances is only the gradient production term, $-\overline{w'T'}\,\partial\theta/\partial z$ or $-\overline{w'q'}\,\partial q/\partial z$. In the daytime, large values of gradient production is seen in temperature variance budget but dissipation is not so large as to balance the production. In the humidity variance budget, relatively large values of negative gradient production is seen in the upper layer because of positive humidity gradient in the upper layer in the daytime. While in the lower layer, positive gradient production is seen in the afternoon. The local time changes and imbalances are also plotted in **Figs. 7 and 8.** Local time change is as small as less than 10% of other terms except in a few cases. All of the terms in Eqs. (4) and (5) are included in the figures but fairly large imbalances are seen in the daytime. Large positive imbalance is seen in the temperature variance budget in the lower layer and large negative imbalance is seen in humidity variance budget in the upper layer.

The mean profiles of the terms in the variance budget equations are shown in **Figs. 9 and 10** for the nighttime and the daytime. In the daytime, prominent decrease of terms with increasing height is seen in the temperature variance budget terms except the gradient production in the highest layer. Zhou *et al.*[10] reported that gradient production shows large value near the top of the mixed layer, but the in-

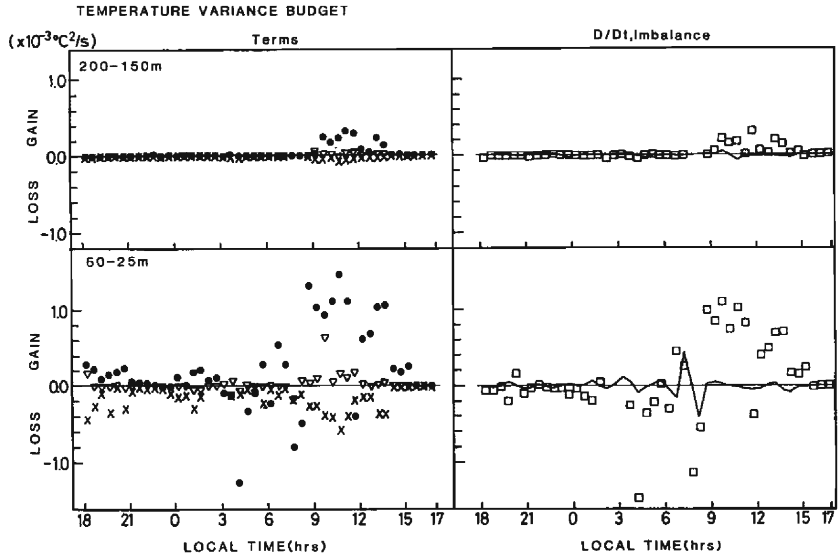

Fig. 7 Diurnal variations of the terms in the temperature variance budget equation for the layer of 200–150 m and 50–25 m. Closed circles are gradient production, triangles are turbulent transport and crosses are dissipation rate. The right half of the figure is the same as Fig. 5 except for the temperature variance budget and imbalance is defined as the (right hand side) —(left hand side) of Eq. (4).

crease in the present data is lower than the top of the mixed layer, which is estimated to be 500 m[3] as a mean value during the daytime (10:00–13:00).

Almost constant values of humidity variance budget terms are seen in the night-

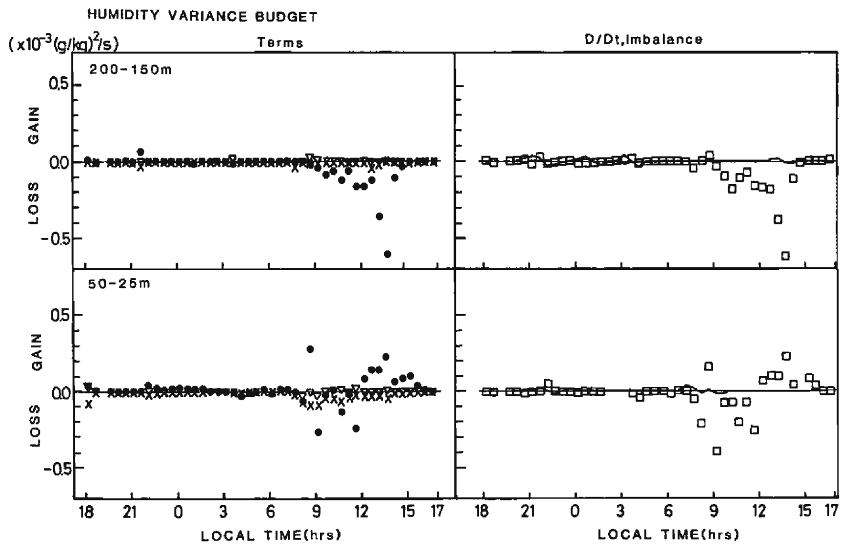

Fig. 8 Same as Fig. 7 except for humidity variance budget

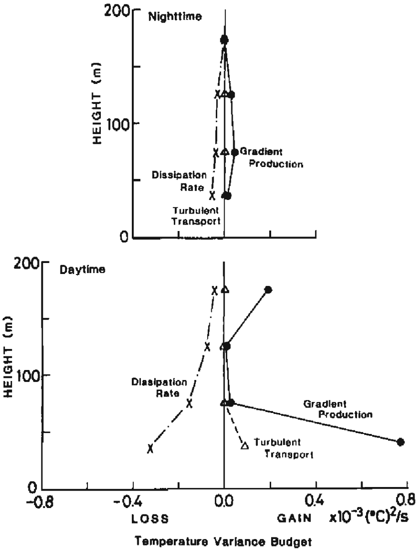

Fig. 9 Same as Fig. 6 except for temperature variance budget

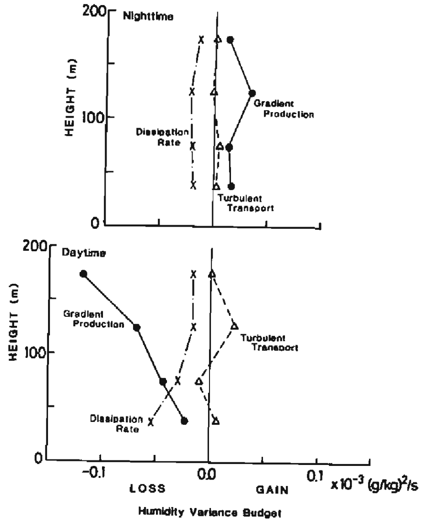

Fig. 10 Same as Fig. 6 except for humidity variance budget

time. Negative gradient production in the humidity variance budget during the daytime is a different situation from the AMTEX data by Lenschow, Wyngaard and Pennell[6] in the unstable planetary boundary layer over ocean. According to their results, the gradient production term is the main source of humidity variance. The turbulent transport term from the lower layer partly compensates for the present loss in the daytime.

3.3 Flux budgets of temperature and humidity

In the flux budget equations, the production terms are composed of a gradient production term and a bouyant production term. The sign of the gradient production term is determined by the sign of $d\theta/dz$ or dq/dz. The buoyant production term in the temperature flux equation is always positive $(g/\theta \overline{T'^2})$ and that in the humidity flux equation depends on the sign of $\overline{T'q'}$. As shown in Tsukamoto[3], the sign of $\overline{T'q'}$ is positive in the daytime and negative in the nighttime. Therefore the buoyant production acts as gain in the daytime and loss in the nighttime.

Figs. 11 and 12 show the diurnal variations of terms of budget equations of temperature flux and humidity flux. The large values of buoyant production $(g/\theta \overline{T'^2})$ in the lower layer is seen in the temperature flux equation around 7:30, corresponding to the high turbulence region appearing at the 50 m level, that is above the top of the mixed layer as mentioned by Tsukamoto[3]. Large negative buoyant production $(g/\theta \overline{T'q'})$ is also seen in the humidity flux budget at the same time and same layer. In the daytime, gradient production terms show almost similar behavior as that in the varaince budget equations because the $\overline{w'^2}$ and $\overline{w'T'}$ or $\overline{w'q'}$ are varying similarly. In the lower layer, large negative gradient production is seen in tempera-

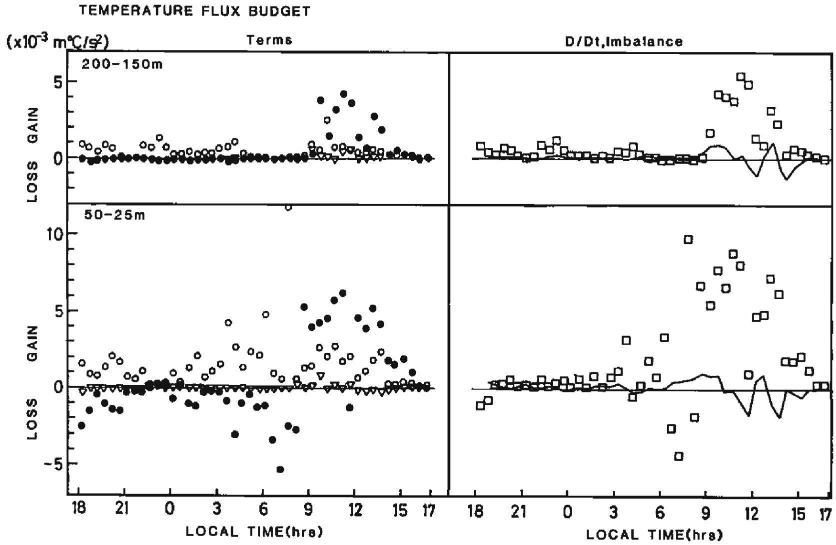

Fig. 11 Diurnal variations of the terms in the temperature flux budget equation for the layer of 200–150 m and 50–25 m. Closed circles are gradient production, open circles are buoyant production and traingles are turbulent transport. The right half of the figure is the same as Fig. 5 except for the temperature flux budget and the imbalance is defined as the (right hand side)—(left hand side) of Eq. (6).

ture flux budget in the early morning, and abruptly changes to a large positive value with the change in sign of potential temperature gradient. While, positive buoyant production in the lower layer is large enough to balance the negative gradient pro-

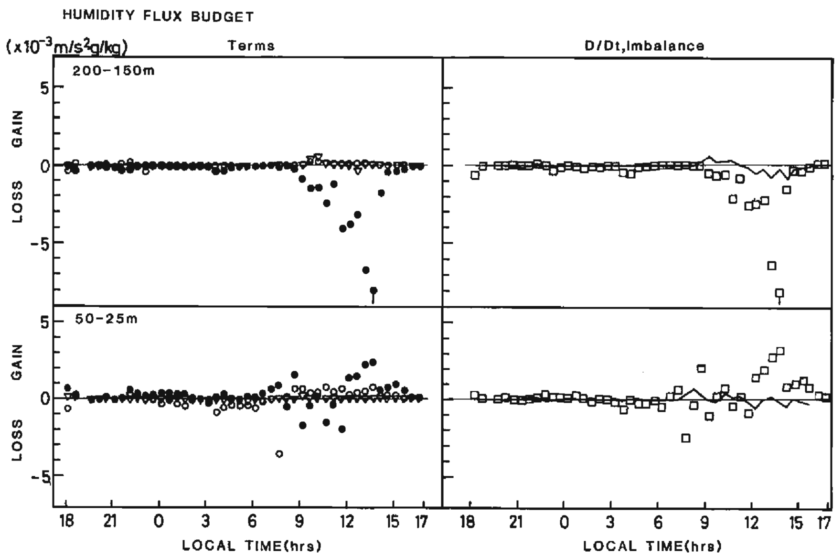

Fig. 12 Same as Fig. 11 except for humidity flux budget

duction in the nighttime and it is about half of the gradient production in the daytime. Turbulent transport terms in the flux budget equations are found to be very small in both fluxes, however their sign changes with height. Local time changes and imbalances are also shown in **Figs. 11** and **12.** Local time change is so small as compared to the other terms and it is plotted as the value increased by 100 times of the raw data. The imbalance is a large positive value in the temperature flux budget in the whole layer and negative in the humidity flux budget in the upper layer. The imbalance includes turbulence-pressure gradient interaction terms such as $\overline{T'\partial p'/\partial z}$ or $\overline{q'\partial p'/\partial z}$, which is not evaluated in the present study.

Mean profiles of flux budget terms are shown in **Figs. 13** and **14.** In the daytime, large values of gain are seen in the temperature flux budget. While in the humidity flux budget equation, large values of negative production is seen especially in the upper layer. This result is different from that of Lenschow, Wyngaard and Pennell[5] over the ocean, that pointed out the importance of gradient production term in the humidity flux budget. In the present case, the loss is partly compensated by buoyant production and turbulent transport in the daytime. In the nighttime, both of the production terms are negative and turbulent transport term shows small positive value. For the temperature flux budget, only the buoyant production acts as gain and a part of it is destroyed by negative gradient production in the nighttime throughout the entire layer.

Fig. 15 shows the vertical profiles of triple correlations, that is vertical transports of turbulent kinetic energy, temperature variance, humidity variance and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ in the daytime mean values. Prominent peaks are seen

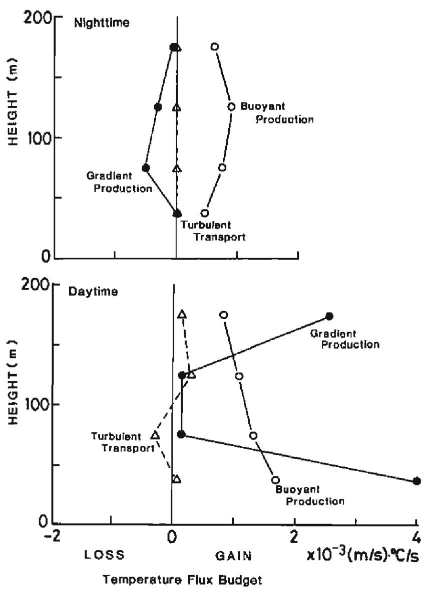

Fig. 13 Same as Fig. 6 except for temperature flux bueget

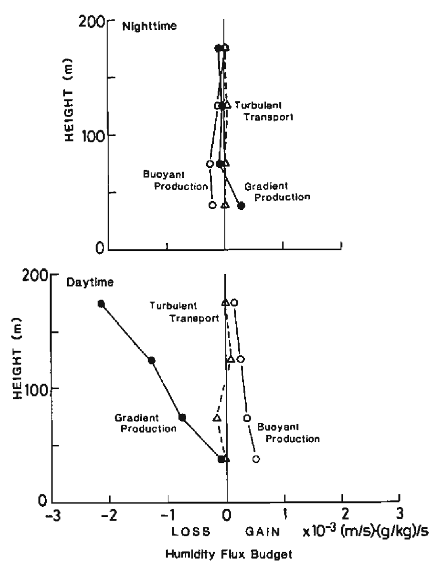

Fig. 14 Same as Fig. 6 except for humidity flux budget

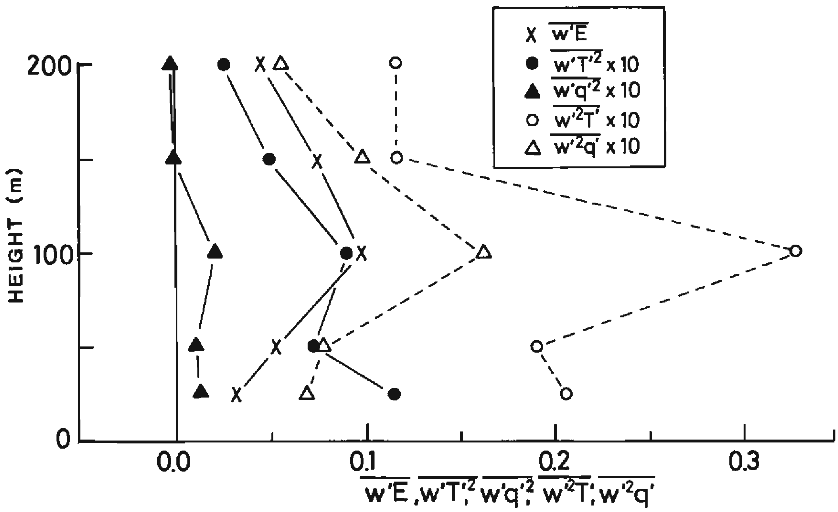

Fig. 15 Mean vertical profiles of triple moments in the turbulence budget equations for the daytime (10:00–13:00) in Run 3031. Units in the abscissa are m/s in w', °C in T' and g/kg in q'.

in all of the triple correlations around the 100 m level. As the turbulent transport terms are represented by the vertical convergences of these values, the turbulent transport terms show negative below 100 m and positive above 100 m. This height is about 1/5 of the mixed layer height, z_i for all of the budget equation in the present case. A similar change in sign of turbulent transport terms are also seen in the previous studies. According to Caughey and Wyngaard[9] and Lenschow, Wyngaard and Pennell[6], the height of 0.3–0.4z_i is the height of change in sign of the turbulent transport term in the turbulent kinetic energy budget. In the variance budget, the height is 0.2–0.3z_i by Zhou *et al.*[10] for temperature variance. Furthermore turbulent transport term in the temperature flux budget changes its sign near 0.1z_i (Lenschow, Wyngaard and Pennell[6], Zhou *et al.*[10]) and near 0.2z_i in humidity flux budget (Lenschow, Wyngaard and Pennell[6]).

4. Conclusion

Turbulence measurement in the planetary boundary layer were carried out on the 213 m meteorological tower including humidity fluctuations.

Heat balance at the ground surface is analyzed. Turbulent fluxes of sensible heat and latnet heat from the surface show almost the same values, 60 W/m^2 and 64 W/m^2 respectively in the daytime mean. Ground heat flux, which is estimated from the residual of heat balance equation, shows heat loss of 2.15 MJ/cm^2 for 23 hours and zero in the daytime.

Budgets of turbulent kinetic energy, temperature variance, humidity variance, temperature flux and humidity flux are analyzed. The similarity of the gradient production terms are not seen between in the budgets of temperature variance and humidity variance, and in those of temperature flux and humidity flux. That is, positive gradient production is seen in the temperature variance and flux, while negative gradient production is seen in the humidity variance and flux especially in the upper layer. It is related to the difference of vertical gradients between potential temperature and specific humidity. Most prominent similarity is seen in the turbulent transport terms for all of the budget equations studied here. The vertical distribution of triple moments have pronounced peaks near the 100 m level in the daytime and as a result, the turbulent transport term changes its sign from negative to positive with the increase of height. This height roughly corresponds to $0.2z_i$. Large imbalances are seen in the budget analysis of variances and fluxes. The reason for this is not clear at present.

Acknowledgement

The author wishes to express his hearty thanks to Prof Y. Mitsuta and Prof N. Monji of Disaster Prevention Research Institute, Kyoto University for their valuable discussions throughout the study. He is also indebt to Dr N. Murayama, Dr T. Hanafusa and Dr T. Fujitani of the Meteorological Research Institute for their arrangements in tower measurements.

The main part of the data processing was made by FACOM M150-F at the Information Center of Disaster Prevention in the Disaster Prevention Research Institute, Kyoto University.

A part of the study was supported by the Ministry of Education, Science and Culture under the grant-in Aid for Research in Special Project No. 58101004 led by Prof. R. Yamamoto.

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Appendix

A. 1 **Hourly mean values of net radiation and solar radiation during the observation. Time of "01" means the duration between 00:00–01:00.**

DATE\TIME	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
<NET RADIATION in W/m^2>																								
28 Oct	-47	-50	-47	-50	-42	-39	-17	47	150	220	270	270	250	172	71	-3	-53	-56	-56	-39	-11	-19	-50	-39
30 Oct	-39	-36	-36	-44	-25	-44	-31	28	117	222	287	281	253	200	111	8	-61	-72	-70	-61	-31	-19	-25	-53
31 Oct	-66	-58	-58	-53	-53	-50	-22	33	136	208	247	172	108	230	47	8	-47	-50	-61	-30	-17	-42	-42	-44
1 Nov	-47	-58	-52	-50	-47	-47	-25	39	138	208	244	250	236	197	114	8	-58	-61	-64	-64	-56	-25	-22	-25
7 Dec	-52	-50	-52	-57	-52	-52	-52	-8	81	159	206	209	183	133	56	-22	-50	-47	-14	-42	-42	-39	-44	-36
<SOLAR RADIATION in W/m^2>																								
28 Oct						0	53	225	405	519	603	608	561	394	205	106	22	0						
30 Oct						0	47	144	372	558	639	661	609	511	255	180	31	0						
31 Oct						0	53	202	386	520	569	375	236	509	172	139	19	0						
1 Nov						0	47	200	372	506	581	586	547	461	322	150	22	0						
7 Dec						0	6	111	278	408	488	497	461	386	258	95	3	0						

A. 2 **Half hourly values of wind direction at the 100m level during the observation (clockwise from north).**

Run 3031						Run 1207			Run 281 - Run 122		
DATE	TIME	WD(deg)	DATE	TIME	WD(deg)	DATE	TIME	WD(deg)	DATE	TIME	WD(deg)
30 Oct	18:00 - 18:30	53	31 Oct	06:00 - 06:30	-26	7 Dec	07:45-08:15	22	28 Oct	14:02-14:36	108
	18:30 - 19:00	64		06:30 - 07:00	-9		08:15-08:45	-15		14:36-15:10	118
	19:00 - 19:30	85		07:00 - 07:30	-3		08:45-09:15	24		15:40-16:14	108
	19:30 - 20:00	72		07:30 - 08:00	-14		09:15-09:45	-8		16:14-16:48	107
	20:00 - 20:30	65		08:00 - 08:30	-30		09:45-10:15	-12		17:10-17:44	106
	20:30 - 21:00	64		08:30 - 09:00	-45		10:15-10:45	-47		17:44-18:18	102
	21:00 - 21:30	71		09:00 - 09:30	-34		10:45-11:15	-48	30 Oct	14:40-15:14	56
	21:30 - 22:00	62		09:30 - 10:00	52		11:15-11:45	-48		15:14-15:48	64
	22:00 - 22:30	72		10:00 - 10:30	101		11:45-12:15	-19		16:15-16:49	75
	22:30 - 23:00	62		10:30 - 11:00	97		12:15-12:45	-15		16:49-17:21	57
	23:00 - 23:30	68		11:00 - 11:30	101		12:45-13:15	-42	1 Nov	12:50-13:24	111
	23:30 - 24:00	62		11:30 - 12:00	102					13:24-13:58	114
31 Oct	00:00 - 00:30	48		12:00 - 12:30	104					15:40-16:14	103
	00:30 - 01:00	57		12:30 - 13:00	117					16:14-16:48	86
	01:00 - 01:30	41		13:00 - 13:30	141						
	01:30 - 02:00	31		13:30 - 14:00	147						
	02:00 - 02:30	15		14:00 - 14:30	133						
	02:30 - 03:00	9		14:30 - 15:00	100						
	03:00 - 03:30	3		15:00 - 15:30	106						
	03:30 - 04:00	-16		15:30 - 16:00	117						
	04:00 - 04:30	-33		16:00 - 16:30	87						
	04:30 - 05:00	-14		16:30 - 17:00	91						
	05:00 - 05:30	-18									
	05:30 - 06:00	-16									

A. 3 Half hourly values of mean wind speed, potential temperature and specific humidity at 6 levels during Run 3031.

T I M E	WIND SPEED ; U (m/s)						POTENTIAL TEMPERATURE ; Θ (°C)						SPECIFIC HUMIDITY ; q (g/kg)					
	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
18:00 - 18:30	7.65	8.40	5.62	3.59	2.16	1.36	12.4	12.3	11.5	10.8	10.4	10.3	3.57	3.27	3.37	3.55	3.65	4.07
18:30 - 19:00	6.52	6.82	5.05	3.55	2.16	1.42	11.7	11.5	10.8	10.1	9.8	9.7	4.47	4.12	3.78	3.68	3.74	4.12
19:00 - 19:30	5.09	4.95	3.96	3.80	2.53	1.52	11.6	11.3	10.8	10.0	9.6	9.3	4.67	4.51	4.24	3.94	3.95	4.25
19:30 - 20:00	4.60	4.70	4.25	3.41	2.03	1.27	11.5	11.2	10.7	9.8	9.5	9.0	4.87	4.90	4.70	4.20	4.17	4.38
20:00 - 20:30	4.04	4.58	4.10	3.62	2.30	1.40	11.5	11.3	11.1	10.3	9.6	8.8	4.91	4.88	4.53	3.99	4.01	4.34
20:30 - 21:00	3.89	4.79	4.26	2.97	1.67	1.12	11.2	11.4	11.2	10.3	9.9	9.3	4.75	4.57	4.03	3.47	3.52	3.89
21:00 - 21:30	3.58	4.19	3.52	2.66	1.65	0.88	11.1	11.2	11.0	10.1	9.7	9.1	4.91	4.63	4.14	3.42	3.49	3.97
21:30 - 22:00	2.89	3.58	3.08	2.40	1.62	0.98	10.9	11.0	10.9	10.1	9.7	9.2	4.65	4.32	3.63	3.20	3.34	3.88
22:00 - 22:30	3.75	5.01	4.65	4.08	2.62	1.55	10.5	10.4	9.7	9.0	8.9	8.7	4.10	3.58	3.52	3.65	3.86	4.27
22:30 - 23:00	3.34	5.08	4.62	3.34	1.97	1.33	10.6	10.3	9.1	8.4	8.4	8.3	3.87	3.49	3.69	3.73	3.86	4.17
23:00 - 23:30	3.64	5.28	3.63	2.61	1.64	1.03	10.1	9.4	8.7	8.0	8.3	7.9	3.65	3.71	3.87	3.70	3.89	4.11
23:30 - 24:00	3.87	5.28	4.29	3.10	2.08	1.39	10.0	9.4	8.5	7.9	8.0	7.6	3.81	3.59	3.85	3.76	3.92	4.17
00:00 - 00:30	5.38	6.14	5.17	4.11	2.91	1.97	9.5	9.4	8.9	8.1	7.8	7.4	3.93	3.68	3.66	3.81	3.96	4.23
00:30 - 01:00	6.48	6.59	4.22	2.63	1.58	1.30	9.1	8.7	8.1	7.3	7.4	7.0	4.21	3.86	3.87	3.81	3.91	4.09
01:00 - 01:30	5.41	6.44	4.89	2.89	1.69	1.67	9.3	8.7	8.0	7.2	6.8	6.0	4.05	3.83	3.78	3.83	3.96	4.27
01:30 - 02:00	5.96	6.22	5.44	3.55	2.57	2.11	9.1	8.8	8.1	6.6	6.1	5.7	4.22	3.85	3.77	3.86	4.00	4.21
02:00 - 02:30	6.24	7.03	4.59	3.11	2.55	1.83	9.4	9.1	7.7	6.8	6.1	5.2	4.08	3.61	3.78	3.85	4.13	4.29
02:30 - 03:00	5.36	6.10	4.27	2.76	2.73	2.07	9.8	9.6	8.0	6.7	5.7	4.5	3.93	3.48	3.59	3.80	4.03	4.20
03:00 - 03:30	4.76	5.38	4.06	2.93	3.09	2.05	9.6	9.6	8.3	7.1	5.9	4.4	3.91	3.49	3.52	3.66	3.86	4.15
03:30 - 04:00	4.46	4.38	3.48	3.10	2.61	1.57	9.5	9.0	8.3	7.4	5.5	4.5	4.10	3.58	3.51	3.55	3.83	4.04
04:00 - 04:30	3.26	3.06	3.26	3.76	2.58	1.77	9.0	9.0	8.6	7.3	5.1	4.3	3.74	3.56	3.54	3.49	3.75	3.99
04:30 - 05:00	2.70	2.86	3.93	3.52	3.16	2.09	9.1	9.1	8.4	7.7	4.6	3.6	3.69	3.52	3.51	3.37	3.70	4.07
05:00 - 05:30	2.23	3.09	3.61	3.02	2.57	1.58	9.1	9.1	8.5	7.7	5.3	3.6	3.81	3.53	3.47	3.33	3.72	4.00
05:30 - 06:00	1.83	2.66	3.12	2.34	2.06	1.54	9.2	9.2	8.5	7.8	4.4	3.6	3.81	3.62	3.49	3.27	3.85	4.00
06:00 - 06:30	2.24	2.63	3.26	2.98	3.36	2.10	9.3	9.1	8.6	7.4	3.7	2.9	3.76	3.54	3.28	3.25	3.70	4.02
06:30 - 07:00	2.20	2.31	2.30	3.17	1.97	1.45	9.4	9.4	9.1	7.3	3.1	3.0	3.77	3.64	3.41	3.43	3.97	4.08
07:00 - 07:30	2.60	2.78	1.63	2.94	2.32	1.95	9.2	9.3	9.2	8.0	2.9	3.1	3.80	3.47	3.47	3.20	3.91	4.18
07:30 - 08:00	2.81	2.84	1.77	2.23	1.88	1.85	9.4	9.5	9.4	6.6	5.0	5.3	3.95	3.51	3.53	3.52	4.11	4.54
08:00 - 08:30	2.74	2.61	1.89	1.64	1.38	1.58	9.6	9.3	8.4	8.0	7.3	7.2	4.22	3.65	4.10	4.55	4.43	4.82
08:30 - 09:00	2.23	2.03	2.12	1.55	1.79	1.99	9.5	9.5	9.1	8.0	9.0	9.1	4.30	3.94	4.16	4.10	4.39	4.89
09:00 - 09:30	1.74	1.86	1.71	1.51	1.73	1.89	9.6	9.7	9.7	9.6	10.2	10.0	4.55	4.36	4.42	4.60	4.34	4.70
09:30 - 10:00	1.48	1.96	1.41	1.24	0.96	1.13	10.6	11.1	10.9	10.8	11.1	11.3	4.81	4.64	4.67	4.40	4.37	4.92
10:00 - 10:30	2.61	3.20	2.58	2.10	1.90	1.56	11.1	11.3	11.3	11.2	11.6	11.9	4.88	4.72	4.67	4.50	4.52	5.04
10:30 - 11:00	2.90	3.46	2.85	2.90	2.33	1.93	11.8	12.0	12.0	11.9	12.2	12.5	5.02	4.85	4.74	4.60	4.51	5.04
11:00 - 11:30	2.25	2.77	2.18	2.28	1.66	1.43	11.9	12.2	12.1	12.1	12.6	12.3	5.13	5.03	4.85	4.80	4.78	5.16
11:30 - 12:00	1.76	2.18	1.93	2.29	1.69	1.28	12.2	12.5	12.5	12.7	12.6	12.6	5.44	5.23	5.08	5.10	4.96	5.36
12:00 - 12:30	1.75	2.18	1.49	1.69	1.16	1.05	12.1	12.3	12.4	12.4	12.9	13.0	5.49	5.20	5.11	5.02	5.16	5.57
12:30 - 13:00	2.19	2.49	2.19	2.33	1.71	1.28	12.4	12.6	12.6	12.6	13.0	13.0	5.65	5.25	5.12	4.99	5.16	5.53
13:00 - 13:30	2.03	2.20	2.21	2.70	2.26	1.59	12.8	13.1	13.0	13.0	13.5	13.5	6.13	5.35	5.21	4.97	5.19	5.59
13:30 - 14:00	2.68	2.66	2.45	2.69	2.05	1.35	13.1	13.2	13.3	13.4	13.7	13.7	6.09	5.36	5.23	5.08	5.29	5.69
14:00 - 14:30	2.44	2.70	2.69	2.85	2.23	1.47	13.2	13.3	13.2	13.2	13.6	13.7	5.96	5.56	5.46	5.33	5.47	5.94
14:30 - 15:00	2.38	2.97	2.51	2.47	1.84	1.43	13.0	13.2	13.0	12.9	13.4	13.4	5.93	5.78	5.66	5.47	5.68	6.07
15:00 - 15:30	2.85	3.18	2.70	2.86	2.27	1.86	13.2	13.3	13.2	13.0	13.4	13.3	6.05	5.91	5.89	5.62	5.81	6.04
15:30 - 16:00	3.02	3.25	2.81	2.79	2.00	1.39	13.4	13.5	13.3	13.2	13.6	13.5	6.10	5.97	5.95	5.72	5.92	6.25
16:00 - 16:30	2.88	3.40	2.75	2.62	1.93	1.45	13.5	13.6	13.4	13.2	13.4	13.2	6.17	6.12	6.10	5.89	6.03	6.36
16:30 - 17:00	2.91	3.75	3.23	3.00	2.10	1.39	13.5	13.6	13.4	13.1	13.1	12.6	6.32	6.29	6.28	6.06	6.25	6.46

A. 4 Half hourly values of turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ at 6 levels during Run 3031.

TIME	$\overline{w'T'}$ (m/s·°C) 200m	150m	100m	50m	25m	10m	$\overline{w'q'}$ (m/s·g/kg) 200m	150m	100m	50m	25m	10m
18:00 - 18:30	0.0039	0.0063	-0.0217	-0.0232	-0.0202	-0.0193	-0.0027	-0.0039	0.0122	0.0107	0.0059	0.0039
18:30 - 19:00	-0.0045	-0.0020	-0.0069	-0.0143	-0.0212	-0.0175	-0.0006	0.0035	-0.0007	0.0039	0.0047	0.0020
19:00 - 19:30	0.0059	-0.0017	-0.0045	-0.0055	-0.0071	-0.0125	—	—	—	—	—	0.0013
19:30 - 20:00	-0.0010	-0.0015	-0.0029	-0.0103	-0.0103	-0.0129	0.0006	0.0002	-0.0016	-0.0016	0.0004	0.0004
20:00 - 20:30	0.0028	0.0011	-0.0052	-0.0052	-0.0068	-0.0072	0.0006	-0.0005	-0.0012	-0.0011	-0.0003	0.0006
20:30 - 21:00	-0.0016	-0.0021	-0.0030	-0.0139	-0.0110	-0.0057	-0.0007	-0.0035	-0.0066	-0.0002	0.0026	0.0024
21:00 - 21:30	-0.0009	-0.0007	-0.0010	-0.0018	-0.0039	-0.0023	0.0002	0.0007	-0.0028	0.0004	0.0014	0.0015
21:30 - 22:00	-0.0032	-0.0021	-0.0072	-0.0029	-0.0022	-0.0046	-0.0105	-0.0107	-0.0164	0.0003	0.0007	0.0014
22:00 - 22:30	-0.0016	-0.0030	-0.0051	-0.0032	-0.0091	-0.0085	-0.0007	0.0004	0.0020	0.0036	0.0075	0.0047
22:30 - 23:00	-0.0016	-0.0061	-0.0011	-0.0037	-0.0071	-0.0067	-0.0020	-0.0010	0.0005	0.0034	0.0065	0.0044
23:00 - 23:30	-0.0037	0.0025	-0.0023	-0.0019	-0.0039	-0.0033	0.0008	-0.0007	0.0017	0.0012	0.0018	0.0012
23:30 - 24:00	-0.0015	-0.0011	-0.0010	-0.0035	-0.0056	-0.0072	0.0017	0.0006	0.0010	0.0021	0.0025	0.0019
00:00 - 00:30	-0.0003	0.0011	0.0097	-0.0071	-0.0128	-0.0122	0.0005	-0.0007	-0.0044	0.0029	0.0038	0.0019
00:30 - 01:00	-0.0000	0.0006	-0.0019	-0.0090	-0.0082	-0.0096	0.0026	-0.0002	0.0005	0.0026	0.0012	0.0014
01:00 - 01:30	-0.0023	0.0001	-0.0014	-0.0125	-0.0084	-0.0072	0.0061	0.0001	0.0006	0.0038	0.0017	0.0011
01:30 - 02:00	0.0021	-0.0009	0.0015	-0.0054	-0.0156	-0.0150	-0.0014	0.0000	-0.0005	0.0014	0.0035	0.0019
02:00 - 02:30	0.0002	0.0014	-0.0040	-0.0021	-0.0025	-0.0071	0.0000	-0.0009	0.0009	0.0005	0.0006	-0.0001
02:30 - 03:00	-0.0005	-0.0008	-0.0020	-0.0005	-0.0042	-0.0034	0.0006	0.0000	0.0004	0.0003	0.0007	0.0005
03:00 - 03:30	0.0004	0.0007	-0.0009	-0.0006	0.0056	-0.0053	-0.0002	-0.0001	0.0003	0.0001	-0.0014	0.0004
03:30 - 04:00	0.0028	-0.0069	-0.0014	0.0046	-0.0004	-0.0005	0.0023	0.0007	0.0003	-0.0013	-0.0001	0.0005
04:00 - 04:30	-0.0077	-0.0043	-0.0019	0.0177	0.0121	-0.0044	0.0048	-0.0018	0.0003	-0.0046	-0.0028	0.0009
04:30 - 05:00	-0.0062	-0.0043	-0.0002	0.0014	0.0042	-0.0058	0.0030	-0.0003	-0.0000	-0.0006	-0.0005	0.0001
05:00 - 05:30	-0.0014	-0.0010	-0.0017	0.0003	0.0020	-0.0015	0.0013	-0.0009	-0.0003	-0.0005	-0.0003	-0.0001
05:30 - 06:00	-0.0007	-0.0014	0.0002	-0.0029	-0.0014	-0.0018	0.0017	-0.0010	0.0002	0.0005	0.0005	0.0001
06:00 - 06:30	-0.0008	-0.0014	0.0004	-0.0014	0.0048	-0.0110	0.0008	-0.0013	0.0005	0.0000	-0.0016	0.0002
06:30 - 07:00	-0.0003	-0.0015	0.0001	-0.0010	-0.0056	-0.0054	0.0008	0.0002	0.0001	0.0008	0.0008	0.0003
07:00 - 07:30	-0.0003	-0.0003	-0.0003	-0.0008	-0.0021	-0.0001	0.0001	0.0002	-0.0001	0.0001	0.0011	0.0018
07:30 - 08:00	0.0002	-0.0007	-0.0004	0.0259	-0.0003	0.0159	0.0007	0.0002	0.0006	-0.0078	0.0071	0.0075
08:00 - 08:30	-0.0001	-0.0005	-0.0008	-0.0006	0.0348	0.0521	-0.0000	0.0000	-0.0008	0.0095	0.0206	0.0191
08:30 - 09:00	-0.0004	-0.0053	-0.0050	0.0221	0.0447	0.0555	-0.0005	0.0055	0.0124	0.0234	0.0250	0.0123
09:00 - 09:30	-0.0030	0.0382	0.0380	0.0328	0.0544	0.0598	0.0042	0.0199	0.0246	0.0312	0.0209	0.0143
09:30 - 10:00	0.0221	0.0361	0.0880	0.0682	0.0730	0.0901	0.0324	0.0176	0.0243	0.0227	0.0227	0.0176
10:00 - 10:30	0.0532	0.0485	0.0811	0.0773	0.0688	0.0863	0.0242	0.0171	0.0162	0.0192	0.0208	0.0184
10:30 - 11:00	0.0500	0.0542	0.0720	0.0996	0.1114	0.1227	0.0495	0.0225	0.0318	0.0399	0.0381	0.0245
11:00 - 11:30	0.0388	0.0565	0.0595	0.0563	0.0695	0.0620	0.0416	0.0255	0.0261	0.0213	0.0245	0.0164
11:30 - 12:00	0.0330	0.0838	0.1018	0.0881	0.1144	0.0685	0.0359	0.0419	0.0570	0.0386	0.0474	0.0221
12:00 - 12:30	0.0268	0.0292	0.0403	0.0348	0.0316	0.0482	0.0380	0.0197	0.0275	0.0170	0.0171	0.0157
12:30 - 13:00	0.0141	0.0182	0.0271	0.0335	0.0457	0.0508	0.0174	0.0143	0.0181	0.0193	0.0248	0.0175
13:00 - 13:30	0.0321	0.0399	0.0537	0.0448	0.0578	0.0695	0.0200	0.0262	0.0177	0.0150	0.0188	0.0195
13:30 - 14:00	0.0481	0.0586	0.0553	0.0737	0.0804	0.0934	0.0342	0.0489	0.0222	0.0264	0.0295	0.0235
14:00 - 14:30	0.0135	0.0138	0.0142	0.0163	0.0116	0.0156	0.0091	0.0185	0.0103	0.0122	0.0101	0.0095
14:30 - 15:00	0.0021	0.0084	0.0076	0.0086	0.0129	0.0159	0.0105	0.0089	0.0070	0.0110	0.0120	0.0077
15:00 - 15:30	-0.0091	-0.0021	0.0043	0.0138	0.0205	0.0196	0.0019	0.0061	0.0082	0.0135	0.0145	0.0050
15:30 - 16:00	0.0008	0.0016	0.0011	0.0005	0.0005	-0.0038	0.0010	0.0042	0.0036	0.0042	0.0062	0.0007
16:00 - 16:30	0.0008	0.0005	-0.0007	-0.0018	-0.0048	-0.0055	0.0008	0.0008	0.0012	0.0018	0.0031	0.0005
16:30 - 17:00	-0.0001	-0.0010	-0.0008	-0.0011	-0.0023	-0.0103	-0.0000	0.0004	-0.0001	0.0009	0.0003	0.0002

A. 5 Half hourly values of Reynolds stress, $\overline{u'w'}$ and variance of vertical velocity, $\overline{w'^2}$ at 6 levels during Run 3031

TIME	$\overline{u'w'}$ (m/s)^2						$\overline{w'^2}$ (m/s)^2					
	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
18:00 - 18:30	0.00907	0.00368	-0.04464	-0.08354	-0.07169	-0.04919	0.0154	0.0219	0.1806	0.2181	0.1656	0.1142
18:30 - 19:00	-0.00076	0.00193	-0.00354	-0.03262	-0.05298	-0.04305	0.0640	0.0437	0.0630	0.1204	0.1340	0.1050
19:00 - 19:30	0.02040	0.00463	0.00239	-0.00967	-0.01313	-0.01907	0.0272	0.0213	0.0166	0.0207	0.0462	0.0480
19:30 - 20:00	0.00342	-0.00153	-0.00003	-0.02097	-0.02311	-0.01771	0.0196	0.0202	0.0266	0.0756	0.0778	0.0692
20:00 - 20:30	0.01228	0.00859	0.00600	-0.00530	-0.01442	-0.01504	0.0250	0.0286	0.0313	0.0471	0.0576	0.0571
20:30 - 21:00	0.00705	0.00661	0.00584	-0.01943	-0.02189	-0.00848	0.0303	0.0357	0.0428	0.0858	0.0762	0.0357
21:00 - 21:30	0.00144	0.00596	0.00104	-0.00249	-0.00838	-0.00064	0.0210	0.0216	0.0130	0.0250	0.0188	0.0174
21:30 - 22:00	0.01086	0.02364	0.02342	0.00983	0.00001	-0.00136	0.0538	0.0313	0.0259	0.0188	0.0151	0.0207
22:00 - 22:30	0.00328	0.00185	0.01123	-0.01046	-0.04520	-0.03741	0.0256	0.0250	0.0234	0.0515	0.1005	0.1018
22:30 - 23:00	0.00260	0.01068	-0.00131	-0.01719	-0.05681	-0.03738	0.0114	0.0132	0.0328	0.0511	0.1069	0.0870
23:00 - 23:30	0.00725	0.00370	-0.00900	-0.00800	-0.01383	-0.00636	0.0074	0.0106	0.0256	0.0296	0.0328	0.0342
23:30 - 24:00	0.00976	0.00717	-0.01265	-0.01071	-0.01912	-0.01430	0.0086	0.0144	0.0615	0.0506	0.0404	0.0350
00:00 - 00:30	-0.00066	-0.00300	0.01373	-0.00309	-0.03361	-0.03659	0.0036	0.0041	0.0306	0.0645	0.0708	0.0942
00:30 - 01:00	0.00066	0.00015	0.00570	-0.02438	-0.03063	-0.02883	0.0062	0.0182	0.0484	0.0961	0.1056	0.0912
01:00 - 01:30	-0.00001	0.00168	0.00089	-0.02520	-0.00282	-0.00486	0.0053	0.0072	0.0306	0.0942	0.0529	0.0199
01:30 - 02:00	0.00455	0.00320	0.00519	-0.01167	-0.00369	-0.01794	0.0071	0.0059	0.0182	0.0488	0.0894	0.0918
02:00 - 02:30	-0.00035	0.00685	-0.00501	0.00081	-0.00088	-0.00868	0.0052	0.0156	0.0259	0.0149	0.0090	0.0190
02:30 - 03:00	0.00127	0.00262	0.00142	0.00042	0.00234	-0.01422	0.0031	0.0046	0.0086	0.0040	0.0046	0.0342
03:00 - 03:30	0.01094	0.00136	0.00033	0.00105	0.00734	-0.00698	0.0067	0.0069	0.0090	0.0052	0.0058	0.0204
03:30 - 04:00	-0.00222	-0.01044	0.00890	0.00433	-0.00018	-0.00389	0.0196	0.0412	0.0317	0.0125	0.0104	0.0072
04:00 - 04:30	-0.01104	0.00084	0.01908	0.00639	0.01071	-0.01214	0.1030	0.0756	0.0635	0.0416	0.0296	0.0213
04:30 - 05:00	-0.00361	0.00753	0.00163	0.00223	0.00197	-0.01274	0.0376	0.0210	0.0149	0.0090	0.0079	0.0269
05:00 - 05:30	0.00442	0.00833	-0.00047	0.00118	0.00822	0.00153	0.0196	0.0159	0.0090	0.0053	0.0046	0.0066
05:30 - 06:00	-0.00028	0.00884	0.00212	0.00444	0.00571	-0.00693	0.0164	0.0104	0.0059	0.0064	0.0130	0.0139
06:00 - 06:30	-0.00195	0.00729	-0.00182	0.00105	0.00397	-0.02222	0.0156	0.0110	0.0088	0.0067	0.0106	0.0392
06:30 - 07:00	-0.00013	0.00635	0.00238	0.00131	-0.00141	-0.01791	0.0106	0.0117	0.0037	0.0106	0.0303	0.0253
07:00 - 07:30	0.00056	-0.00169	0.00214	-0.00024	-0.00849	-0.02365	0.0055	0.0067	0.0055	0.0166	0.0324	0.0557
07:30 - 08:00	0.00031	-0.00290	0.00434	0.01866	-0.03571	-0.03673	0.0123	0.0130	0.0090	0.0190	0.0595	0.0847
08:00 - 08:30	-0.00002	-0.00143	0.00341	-0.01055	-0.04204	-0.01830	0.0029	0.0106	0.0135	0.0520	0.1399	0.1347
08:30 - 09:00	-0.00567	-0.00923	0.01377	-0.01686	-0.01647	-0.01685	0.0182	0.0317	0.0841	0.1129	0.1648	0.1452
09:00 - 09:30	0.00225	-0.01033	-0.01692	0.02735	0.01438	-0.01517	0.1840	0.2560	0.2642	0.1706	0.1689	0.1225
09:30 - 10:00	-0.10588	0.02313	-0.04597	-0.09718	-0.06483	-0.00607	0.4134	0.4290	0.5098	0.3411	0.3181	0.2285
10:00 - 10:30	-0.02058	-0.08369	-0.09129	-0.10110	-0.07482	-0.04663	0.4070	0.4570	0.4844	0.3528	0.2530	0.1858
10:30 - 11:00	0.10217	0.05706	0.04739	-0.06440	-0.12534	-0.04554	0.8082	0.6512	0.5898	0.4529	0.3832	0.3047
11:00 - 11:30	-0.00583	0.06449	-0.02403	-0.05655	-0.08637	-0.04746	0.6708	0.5685	0.4984	0.3869	0.3318	0.2043
11:30 - 12:00	0.01215	-0.02766	0.05296	-0.08596	-0.12964	-0.04817	0.6336	0.8172	0.7157	0.3869	0.3025	0.1681
12:00 - 12:30	0.01573	0.01132	0.00751	0.01484	-0.02470	0.01713	0.4789	0.4529	0.4970	0.3014	0.2007	0.1697
12:30 - 13:00	0.03076	0.01083	-0.03227	-0.02201	-0.05222	-0.04291	0.2683	0.2673	0.2862	0.2490	0.2107	0.1576
13:00 - 13:30	-0.00321	0.00048	-0.07834	-0.02352	-0.04148	-0.07410	0.4409	0.4147	0.3969	0.2927	0.2304	0.1945
13:30 - 14:00	0.01478	0.04018	-0.04012	-0.04596	-0.07118	-0.01742	0.7744	0.6115	0.4020	0.3058	0.3025	0.2381
14:00 - 14:30	0.00027	0.02103	0.04126	0.00293	-0.00561	-0.02687	0.2218	0.2209	0.2153	0.1429	0.0973	0.1183
14:30 - 15:00	0.02884	0.00704	-0.01308	-0.03534	-0.06587	-0.03767	0.1459	0.1391	0.1082	0.0961	0.1011	0.1043
15:00 - 15:30	-0.01773	-0.00913	-0.03682	-0.07970	-0.08669	-0.05256	0.1043	0.1129	0.1325	0.1325	0.1369	0.1399
15:30 - 16:00	0.00518	-0.00408	-0.02144	-0.01641	-0.04404	-0.02458	0.0812	0.0751	0.0778	0.0784	0.0918	0.0986
16:00 - 16:30	0.00596	0.00631	0.00168	-0.00570	-0.01260	-0.01810	0.0253	0.0204	0.0259	0.0400	0.0502	0.0625
16:30 - 17:00	0.00348	0.00717	0.01085	-0.00332	-0.00769	-0.01868	0.0177	0.0219	0.0219	0.0216	0.0296	0.0484

A. 7 Half hourly values of triple moments, $\overline{w'E}$, $\overline{w'T'^2}$ and $\overline{w'q'^2}$ at 6 levels during Run 3031.

TIME	$\overline{w'E}$ ($\times10^{-3}$ m^3/s^3)						$\overline{w'T'^2}$ ($\times10^{-3}$ m/s·(°C)^2)						$\overline{w'q'^2}$ ($\times10^{-3}$ m/s·(g/kg)^2)					
	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
18:00 - 18:30	-2.9	-0.6	27.6	-8.3	-6.2	-13.1	-0.62	-0.54	0.38	-7.35	-2.50	-1.21	-0.34	-0.29	-0.93	-3.03	-0.75	-0.08
18:30 - 19:00	1.4	1.9	9.8	3.6	13.5	-8.4	0.16	0.35	2.08	-0.05	-0.09	0.98	0.08	-0.25	-0.49	-0.05	-0.04	-0.02
19:00 - 19:30	-3.1	-1.5	2.8	-0.1	2.0	-1.0	-0.15	-0.15	0.52	0.46	0.04	-0.38	—	—	—	—	—	-0.01
19:30 - 20:00	0.3	0.6	-0.8	2.6	2.8	-1.1	-0.19	-0.01	0.06	-0.24	-0.04	0.55	-0.01	-0.05	0.07	-0.04	-0.02	0.00
20:00 - 20:30	-0.4	0.2	0.0	-0.2	1.5	-0.7	-0.02	0.16	-0.05	-0.17	-0.39	-0.70	-0.02	0.00	-0.01	0.02	0.02	-0.01
20:30 - 21:00	-1.2	0.0	-0.8	-1.1	6.0	-1.4	-0.13	-0.03	-0.24	-0.64	-1.68	-0.33	-0.11	0.24	-0.40	-0.00	0.04	-0.06
21:00 - 21:30	1.0	1.0	0.2	0.5	0.5	-0.3	0.00	-0.02	0.03	0.17	0.86	-0.18	0.18	0.46	0.03	0.03	0.05	-0.07
21:30 - 22:00	-5.0	-3.4	-4.7	-3.1	-0.4	-1.3	-0.11	0.01	-0.28	-0.18	-0.06	0.00	-0.24	0.06	-3.85	-0.03	-0.07	0.02
22:00 - 22:30	-1.6	-1.4	-0.9	2.0	8.6	-7.3	0.02	-0.42	0.54	0.42	1.00	-0.06	-0.64	-1.92	0.32	0.14	0.62	0.02
22:30 - 23:00	0.3	-0.9	1.2	1.1	4.4	-5.7	0.01	-0.40	0.58	0.06	0.14	-0.03	0.21	-0.02	0.17	-0.01	0.08	-0.08
23:00 - 23:30	0.7	0.9	1.7	-0.1	-1.2	-0.2	-0.41	1.44	0.07	-0.01	0.15	-0.23	-0.08	0.30	0.02	-0.01	0.01	-0.02
23:30 - 24:00	1.0	-1.1	4.1	-0.4	2.0	-2.5	0.18	-0.29	1.44	-0.16	0.26	-0.27	0.08	-0.03	0.37	-0.06	-0.01	-0.03
00:00 - 00:30	0.6	0.3	-5.2	-4.3	4.9	1.3	0.08	-0.02	-1.17	-0.01	0.39	0.50	0.01	0.00	-0.26	-0.00	-0.07	-0.05
00:30 - 01:00	-0.1	0.3	-1.5	-4.1	1.3	-2.9	-0.01	0.29	0.62	0.08	-0.15	-0.12	0.21	0.01	0.11	-0.02	-0.01	0.01
01:00 - 01:30	-0.6	0.1	0.6	-5.2	-2.2	-0.5	-0.09	0.00	0.27	0.78	-1.42	-1.92	-0.48	-0.01	0.04	-0.27	-0.13	-0.07
01:30 - 02:00	0.8	0.4	0.2	8.5	-2.5	-1.1	0.18	0.06	-0.07	0.53	-2.19	-2.52	0.04	0.00	0.00	-0.02	-0.19	-0.01
02:00 - 02:30	-0.1	-0.3	0.5	-0.2	0.2	0.4	0.01	0.02	0.03	-0.06	0.11	0.01	0.11	0.00	-0.02	-0.00	-0.00	-0.00
02:30 - 03:00	-0.2	-0.3	0.4	-0.1	0.0	-0.3	-0.01	-0.04	-0.10	-0.02	0.65	-0.07	0.07	-0.00	-0.00	-0.00	0.03	-0.00
03:00 - 03:30	-2.7	0.9	0.3	0.0	0.7	-0.2	-0.17	0.56	0.20	-0.05	1.56	-0.15	-0.21	0.03	0.02	-0.01	0.07	-0.01
03:30 - 04:00	-0.3	1.5	-1.8	0.1	0.2	0.0	-0.41	-0.08	-0.10	-4.50	-0.30	-0.35	-2.44	-0.02	-0.02	-0.24	-0.02	0.00
04:00 - 04:30	10.2	-6.5	-0.1	1.3	-0.1	2.3	0.37	-0.30	0.34	2.48	-1.01	0.86	-0.00	-0.02	-0.02	0.26	-0.03	0.04
04:30 - 05:00	-2.4	-2.3	-0.1	-0.1	0.4	1.5	-0.45	-0.32	-0.10	-0.28	0.90	0.05	-0.03	0.02	-0.00	-0.03	-0.02	-0.00
05:00 - 05:30	-0.2	-0.0	0.4	0.2	-0.8	0.3	-0.04	0.00	-0.13	0.18	-3.71	0.05	-0.03	-0.00	-0.02	0.00	-0.16	-0.02
05:30 - 06:00	-0.2	-0.1	0.1	0.4	-0.6	-1.0	0.00	0.00	0.00	-0.04	-0.12	0.04	-0.00	-0.02	0.00	-0.01	-0.03	0.00
06:00 - 06:30	0.4	-0.2	0.1	0.2	1.5	0.9	-0.02	0.00	0.00	0.44	0.63	0.34	0.01	-0.01	0.02	0.00	-0.02	-0.00
06:30 - 07:00	-0.3	-0.3	-0.1	-0.1	0.2	-0.9	0.00	-0.02	-0.02	-0.08	-0.49	-0.09	-0.00	-0.00	-0.00	0.01	-0.02	-0.00
07:00 - 07:30	0.1	0.1	-0.0	0.0	2.2	-0.0	-0.01	-0.01	0.00	-0.22	0.05	0.02	0.00	0.00	-0.00	-0.01	0.02	-0.00
07:30 - 08:00	-0.0	0.5	-0.5	1.0	11.2	1.2	0.04	0.00	-0.01	10.00	-0.10	1.25	0.00	0.00	-0.02	0.98	0.53	0.20
08:00 - 08:30	0.1	-0.3	0.5	2.9	17.2	0.2	0.00	0.00	0.07	0.08	4.05	6.93	0.00	0.00	0.04	1.31	-0.38	0.33
08:30 - 09:00	0.2	8.7	12.3	24.6	20.4	14.0	0.05	1.28	0.54	2.95	4.99	8.76	0.04	4.38	3.11	-0.91	-0.97	0.13
09:00 - 09:30	31.6	82.8	39.0	25.2	21.0	10.6	2.41	9.69	3.08	1.69	6.70	8.38	0.63	2.56	2.44	3.90	2.23	0.87
09:30 - 10:00	41.2	48.6	108.0	21.6	13.6	17.5	0.60	4.17	14.69	21.99	53.50	39.89	-0.74	0.54	1.03	0.99	1.93	0.59
10:00 - 10:30	-10.1	60.3	41.9	61.2	29.9	6.4	2.31	4.90	4.78	3.53	6.43	28.39	0.35	-3.45	0.93	0.09	0.23	1.61
10:30 - 11:00	127.0	60.6	46.6	141.0	79.8	11.9	2.92	2.86	10.80	14.60	23.19	35.50	-1.19	0.24	1.59	1.19	2.11	0.83
11:00 - 11:30	38.1	112.0	156.0	62.1	16.7	9.5	4.17	9.53	13.09	6.98	12.89	18.09	-0.59	0.71	1.48	0.60	0.94	0.39
11:30 - 12:00	48.6	202.0	257.0	51.8	97.7	33.1	4.96	11.19	21.39	14.40	23.39	16.39	0.27	1.17	7.33	3.06	4.43	1.70
12:00 - 12:30	38.2	2.9	19.1	-25.0	-26.0	-8.8	0.87	0.62	3.16	2.13	0.87	12.20	-0.51	0.11	0.56	0.33	0.07	1.39
12:30 - 13:00	44.8	21.8	78.5	43.8	6.9	-1.5	1.09	1.43	2.30	3.32	3.88	7.81	16.40	0.41	0.95	1.15	0.41	0.72
13:00 - 13:30	76.5	102.0	113.0	35.6	20.5	32.4	3.94	6.68	7.92	6.00	7.76	13.79	0.30	0.31	1.08	0.69	0.74	1.14
13:30 - 14:00	24.7	59.1	97.2	59.9	10.6	16.3	5.69	8.85	9.89	14.09	16.89	26.39	0.28	0.76	1.20	1.50	2.04	1.33
14:00 - 14:30	52.4	50.4	58.2	31.4	11.7	12.7	0.45	1.17	0.97	0.69	0.38	0.95	0.28	0.74	0.58	0.32	0.21	-0.14
14:30 - 15:00	9.7	19.3	15.7	8.9	0.7	-7.4	0.22	0.81	0.54	0.22	0.67	1.30	0.11	0.49	0.31	0.44	0.18	0.10
15:00 - 15:30	35.0	22.8	18.7	44.5	35.5	12.3	0.38	-0.04	-0.01	0.28	0.97	0.88	0.06	0.24	0.30	0.53	0.16	-0.04
15:30 - 16:00	3.7	0.1	1.2	-3.5	-5.0	-1.1	-0.09	-0.02	-0.05	0.03	0.04	-0.03	0.03	0.10	0.13	0.10	0.10	-0.05
16:00 - 16:30	1.1	0.9	1.9	2.3	1.6	-1.7	-0.01	-0.02	0.02	0.02	0.09	-0.16	0.00	0.01	0.05	0.06	0.03	-0.04
16:30 - 17:00	-0.8	-1.2	0.1	-0.5	0.2	-1.2	-0.01	0.01	0.00	0.04	0.23	0.09	-0.05	-0.10	-0.02	0.01	0.01	-0.01

A. 8 Half hourly values of covariance, $T'q'$ and triple moments $\overline{w'^2T'}$ and $\overline{w'^2q'}$ at 6 levels during Run 3031

TIME	$\overline{T'q'}$ ($\times10^{-3}$ °C·g/kg)						$\overline{w'^2T'}$ ($\times10^{-3}$ (m/s)^2°C)						$\overline{w'^2q'}$ ($\times10^{-3}$ (m/s)^{2}g/kg)					
	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
18:00 - 18:30	-7.0	-21.2	-60.1	-22.0	-16.4	-4.1	-1.12	0.05	12.60	14.80	7.86	3.69	0.65	-0.01	7.07	-9.47	-4.08	-0.73
18:30 - 19:00	2.4	12.5	-5.0	-4.0	-5.7	-3.2	-0.79	0.05	-5.27	0.86	-1.04	2.71	1.91	0.57	8.00	-0.37	0.05	-0.50
19:00 - 19:30						-2.0	0.25	0.31	-0.19	-0.63	-0.92	0.86	—	—	—	—	—	-0.08
19:30 - 20:00	-3.4	-4.5	7.8	5.0	1.2	-0.2	-0.24	-0.01	-0.88	-0.79	-0.43	1.62	0.01	-0.05	-0.30	0.02	0.53	0.08
20:00 - 20:30	-1.1	0.3	2.1	3.4	-1.4	-0.8	0.01	0.03	0.18	-0.66	0.07	0.62	-0.33	0.02	-0.08	-0.03	0.30	-0.09
20:30 - 21:00	5.0	4.6	10.4	1.7	-11.6	-6.2	-0.36	0.06	-0.83	0.79	3.31	0.61	-0.22	0.13	-0.95	0.32	-0.60	-0.25
21:00 - 21:30	2.3	2.6	2.0	-0.5	-7.6	-6.6	0.03	0.00	0.13	-0.16	0.29	0.39	0.17	-0.85	0.10	0.05	-0.03	-0.19
21:30 - 22:00	4.7	6.8	26.3	-3.0	-4.9	-6.5	0.85	0.42	0.76	0.00	-0.05	0.16	1.77	0.89	1.84	0.35	0.08	-0.13
22:00 - 22:30	9.3	12.3	-51.0	-26.6	-16.9	-2.6	-0.03	0.40	0.46	-3.35	-3.57	0.23	0.05	0.32	-0.18	2.27	3.01	0.00
22:30 - 23:00	5.2	-1.6	-11.8	-1.8	-2.3	-1.7	-0.10	-0.27	-0.47	-0.03	-0.52	0.87	-0.22	-0.06	0.33	0.16	0.61	-0.57
23:00 - 23:30	-10.4	-18.0	-2.1	-1.1	-1.8	-1.6	-0.43	0.08	-0.17	0.00	-0.22	0.79	0.14	-0.05	0.09	-0.08	0.01	-0.13
23:30 - 24:00	-2.5	-6.0	-8.8	-3.4	-3.8	-2.6	0.08	-0.42	0.00	0.97	0.01	0.44	0.00	0.16	0.15	-0.41	-0.10	-0.21
00:00 - 00:30	-0.2	-2.9	-22.1	-7.8	-9.7	-2.1	0.06	0.00	-3.87	2.25	-0.49	0.62	0.00	0.00	1.58	-0.60	-0.18	0.02
00:30 - 01:00	-1.9	-2.5	-10.8	-3.3	-2.3	-1.2	-0.04	-0.33	-1.35	-0.18	1.06	0.44	-0.11	0.06	0.46	-0.03	-0.36	-0.12
01:00 - 01:30	-15.0	-2.0	-5.5	-5.7	-11.4	-4.4	0.08	0.07	-0.99	-0.26	1.94	0.40	-0.42	-0.01	0.32	-0.16	-0.55	-0.19
01:30 - 02:00	-2.5	-0.9	-1.3	-17.9	-10.5	-1.5	0.08	0.09	0.10	-0.38	1.83	4.36	0.01	0.00	-0.04	0.08	-0.92	0.01
02:00 - 02:30	0.9	-5.3	-7.4	-3.1	-5.2	-0.1	0.00	0.11	-0.12	0.33	-0.14	-0.09	-0.06	-0.02	0.07	-0.10	0.00	0.02
02:30 - 03:00	0.2	-3.3	-3.6	-1.4	-9.8	-1.1	0.00	-0.02	-0.02	0.02	-0.18	-0.36	-0.02	-0.02	0.03	0.00	0.03	-0.02
03:00 - 03:30	-0.3	-5.4	-10.6	-1.3	-18.4	-2.8	0.18	-0.36	-0.24	0.02	-0.18	-0.07	-0.33	0.09	0.08	0.00	0.03	0.00
03:30 - 04:00	-5.6	-5.0	-3.5	-23.2	-27.5	-3.4	-0.32	0.68	0.44	-1.19	-0.37	0.12	0.77	0.04	-0.23	0.22	0.08	0.01
04:00 - 04:30	-10.1	-4.2	-7.7	-5.8	-25.0	-2.6	0.22	1.00	1.91	0.68	-1.50	-0.54	-0.28	-0.33	-0.68	-0.76	0.42	0.05
04:30 - 05:00	-1.4	-1.4	-3.1	-2.0	-24.5	0.1	1.53	1.12	0.27	0.05	0.05	-0.12	-0.40	-0.23	-0.07	-0.03	0.00	0.02
05:00 - 05:30	-0.6	0.1	-1.1	-2.7	-24.7	-1.5	0.14	0.00	-0.10	-0.38	-0.43	-0.13	-0.16	0.00	-0.04	0.02	0.09	0.04
05:30 - 06:00	-1.2	0.7	-0.4	-2.8	-20.9	-1.2	-0.05	0.06	0.03	-0.13	0.03	0.15	0.02	0.04	0.00	0.04	-0.01	0.00
06:00 - 06:30	-2.0	-1.1	-2.0	-9.5	-21.0	-1.0	-0.05	0.05	0.11	-0.18	-0.37	0.03	0.11	0.02	-0.06	0.00	0.00	-0.03
06:30 - 07:00	-0.0	-0.3	0.9	-6.1	-3.3	-0.3	0.00	0.04	0.01	-0.35	0.00	0.13	0.00	-0.06	0.01	0.09	0.00	0.00
07:00 - 07:30	0.3	-0.2	0.0	-2.7	-1.0	0.1	0.02	0.00	0.00	-0.16	-0.30	-0.16	0.03	0.00	-0.04	-0.01	0.20	-0.01
07:30 - 08:00	4.2	0.1	-0.7	-209.0	-0.4	4.9	0.07	0.01	0.07	0.73	-0.16	0.82	0.24	0.02	-0.09	-0.25	2.46	-0.10
08:00 - 08:30	0.3	-0.1	1.3	-1.7	10.9	14.5	-0.01	0.02	-0.17	1.20	6.94	3.46	-0.01	0.01	-0.13	4.28	2.23	0.56
08:30 - 09:00	2.6	-3.8	-18.0	15.4	24.1	13.5	-0.13	-2.90	-1.14	6.49	6.62	8.42	-0.11	5.35	14.29	6.25	3.71	2.88
09:00 - 09:30	1.6	0.9	3.9	12.9	22.0	20.3	6.49	31.69	7.92	7.10	11.19	5.44	-0.94	12.40	12.80	8.01	5.60	1.91
09:30 - 10:00	4.1	9.7	8.7	10.3	14.0	17.1	4.48	10.09	52.00	12.80	33.69	24.39	-0.25	22.09	13.90	4.42	10.60	27.30
10:00 - 10:30	2.1	11.5	6.0	10.9	16.2	21.3	7.22	15.29	15.90	13.30	13.99	31.50	3.45	31.79	7.38	4.25	4.06	6.59
10:30 - 11:00	6.3	3.7	11.2	20.9	29.5	27.7	13.59	3.10	20.29	33.69	42.89	43.89	2.78	0.89	7.32	11.30	13.70	8.11
11:00 - 11:30	5.3	4.9	7.9	12.1	17.2	14.0	13.79	40.39	57.50	23.79	25.69	16.19	-1.21	8.74	19.69	7.52	6.66	1.98
11:30 - 12:00	4.2	6.2	12.8	15.1	28.1	31.1	26.19	57.69	89.29	27.29	34.09	9.98	6.98	16.59	56.19	13.59	16.69	2.09
12:00 - 12:30	3.4	1.7	5.7	7.0	6.6	11.3	6.65	-2.98	8.48	5.84	0.99	8.03	0.35	-0.22	2.50	2.85	-0.77	-2.19
12:30 - 13:00	3.8	3.0	6.4	10.8	12.0	24.6	3.46	1.25	5.69	10.80	7.32	6.71	21.99	1.96	6.08	7.44	3.00	22.90
13:00 - 13:30	6.1	4.5	7.3	11.1	18.3	32.8	14.49	19.49	30.29	11.69	9.41	11.19	3.91	4.62	13.59	5.55	3.50	24.40
13:30 - 14:00	1.2	6.5	8.8	16.6	29.1	32.0	21.89	26.69	24.39	20.19	12.49	23.49	12.40	5.75	8.88	7.05	5.60	60.90
14:00 - 14:30	1.1	2.8	3.4	3.5	4.8	5.6	4.65	2.60	5.83	4.76	1.62	2.26	3.66	5.86	5.66	2.85	1.52	6.18
14:30 - 15:00	0.5	1.7	2.7	4.2	5.2	5.2	1.19	3.65	0.90	1.02	1.76	0.90	0.84	3.07	1.25	1.31	0.95	1.80
15:00 - 15:30	-0.1	-0.7	1.1	3.8	5.7	0.4	-3.63	-0.99	1.03	4.22	4.76	1.84	1.12	2.47	2.47	3.55	2.60	2.37
15:30 - 16:00	-0.0	-0.9	0.4	1.7	0.8	0.8	-0.45	0.72	0.45	0.49	-0.95	-0.80	0.26	0.96	0.69	0.57	0.29	-2.30
16:00 - 16:30	0.3	-0.3	-0.4	-0.6	-2.4	-1.6	0.06	-0.10	-0.04	-0.18	-0.54	0.07	0.10	0.07	0.16	0.36	0.46	-1.15
16:30 - 17:00	0.0	-0.4	-0.4	-1.9	-2.3	-1.0	0.05	0.07	-0.38	-0.16	-0.65	0.48	-0.11	-0.37	-0.05	0.26	0.21	0.99

A.10 Half hourly values of mean wind speed, potential temperature and temperature flux, $\overline{w'T'}$ at 6 levels during Run 1207

	WIND SPEED(m/s)						POTENTIAL TEMPERATURE(°C)						TEMPERATURE FLUX ; $\overline{w'T'}$ (m/s·°C)					
TIME	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
7:45- 8:15	2.79	1.58	0.81	0.74	0.53	0.77	5.5	5.1	4.6	1.4	-0.8	-0.7	0.0049	0.0004	-0.0028	-0.0071	0.0002	0.0025
8:15- 8:45	3.91	2.38	0.68	0.60	0.29	0.39	6.0	5.5	4.8	2.9	0.5	0.1	-0.0047	-0.0033	0.0044	-0.0482	0.0080	0.0049
8:45- 9:15	2.96	1.55	1.63	1.01	0.78	0.79	5.8	5.4	4.9	3.6	3.0	3.1	0.0159	-0.0128	-0.0272	0.0007	0.0138	0.0226
9:15- 9:45	5.04	3.73	2.99	1.80	1.88	1.85	6.8	6.2	5.7	4.5	5.1	5.4	-0.0017	0.0009	-0.0049	0.0165	0.0458	0.0513
9:45-10:15	4.26	3.14	3.03	1.99	2.01	1.98	7.1	6.8	6.7	8.5	6.6	6.9	-0.0193	-0.0307	0.0121	0.0447	0.0783	0.0808
10:15-11:15	3.25	3.12	3.17	2.35	1.94	1.78	7.4	7.6	7.4	7.4	7.7	7.9	0.0348	0.0481	0.0555	0.0899	0.1331	0.1126
11:15-11:45	3.56	3.62	3.90	3.17	2.82	2.48	7.7	7.9	7.9	7.7	8.1	8.3	0.0450	0.0617	0.0778	0.1189	0.1417	0.1345
11:45-12:15	3.59	3.72	3.78	2.70	2.23	2.11	8.0	8.2	8.3	8.2	8.5	8.6	0.0328	0.0495	0.0527	0.1013	0.1258	0.1146
11:45-12:15	3.77	3.84	4.14	3.47	3.03	2.71	8.4	8.7	8.6	8.6	8.8	9.0	0.0373	0.0512	0.0590	0.0719	0.1183	0.1301
12:15-12:45	2.53	2.47	2.80	2.11	1.78	1.66	8.9	9.1	9.1	8.9	9.1	9.4	0.0380	0.0449	0.0802	0.0791	0.1028	0.1162
12:45-13:15	2.18	2.00	2.18	1.51	1.37	1.44	9.2	9.5	9.5	9.4	9.6	9.8	0.0437	0.0547	0.0712	0.0879	0.0965	0.0867

A.11 Half hourly values of Reynolds stress, $\overline{u'w'}$ and variances of vertical velocity, $\overline{w'^2}$ at 6 levels during Run 1207

	$\overline{u'w'}$ (m/s)^2						$\overline{w'^2}$ (m/s)^2					
TIME	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
7:45- 8:15	0.0058	-0.0018	0.0006	0.0126	0.0004	-0.0129	0.0342	0.0542	0.0357	0.0253	0.0161	0.0234
8:15- 8:45	-0.0063	-0.0017	-0.0079	-0.0051	0.0091	0.0106	0.0368	0.0462	0.0285	0.0313	0.0295	0.0302
8:45- 9:15	0.0331	-0.0304	0.0115	0.0039	0.0226	-0.0020	0.0600	0.0723	0.1004	0.0846	0.0823	0.0729
9:15- 9:45	0.0222	0.0036	-0.0419	-0.0308	-0.0464	-0.0367	0.0357	0.0484	0.0876	0.1414	0.1739	0.1413
9:45-10:15	-0.0496	-0.1052	-0.0965	-0.0482	-0.0826	-0.0753	0.2460	0.3036	0.3260	0.3025	0.2819	0.2199
10:15-10:45	-0.3808	-0.2834	-0.1478	-0.1399	-0.1887	-0.1208	0.6400	0.6496	0.5212	0.4914	0.4395	0.3169
10:45-11:15	-0.1553	-0.1593	-0.1545	-0.2682	-0.2785	-0.2258	0.5776	0.5806	0.5840	0.4684	0.4435	0.3969
11:15-11:45	-0.0760	-0.0956	-0.0602	-0.2114	-0.1861	-0.1310	0.5299	0.5314	0.4422	0.4199	0.3844	0.3505
11:45-12:15	-0.0600	-0.0004	-0.0153	-0.0538	-0.1695	-0.1872	0.6609	0.6052	0.4173	0.2862	0.3528	0.3881
12:15-12:45	-0.1145	-0.0463	-0.0609	-0.0845	-0.1085	-0.0632	0.5285	0.4970	0.4774	0.3616	0.3410	0.2992
12:45-13:15	-0.1045	-0.0701	-0.0871	-0.1096	-0.0964	-0.0652	0.5882	0.5565	0.4489	0.3540	0.2959	0.1998

A.12 Half hourly values of turbulent kinetic energy, E and temperature variance, $1/2\overline{T'^2}$ at 6 levels during Run 1207

	E (m^2/s^2)						$\frac{1}{2}\overline{T'^2}$ (°C)^2					
TIME	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
7:45 - 8:15	0.086	0.144	0.089	0.140	0.104	0.123	0.0141	0.0062	0.0039	0.2366	0.0074	0.0050
8:15 - 8:45	0.184	0.244	0.113	0.120	0.187	0.165	0.0154	0.0310	0.0173	0.3208	0.0204	0.0087
8:45 - 9:15	0.294	0.225	0.199	0.154	0.143	0.153	0.0508	0.0235	0.0788	0.1021	0.0089	0.0163
9:15 - 9:45	0.214	0.142	0.246	0.252	0.263	0.271	0.0081	0.0111	0.0089	0.0096	0.0176	0.0317
9:45 - 10:15	0.702	0.646	0.612	0.539	0.632	0.589	0.0227	0.0210	0.0089	0.0151	0.0327	0.0512
10:15 - 10:45	1.074	1.231	0.887	0.822	0.862	0.807	0.0058	0.0074	0.0128	0.0121	0.0496	0.0699
10:45 - 11:15	0.751	0.865	0.897	1.106	1.247	1.120	0.0082	0.0100	0.0149	0.0429	0.0648	0.0890
11:15 - 11:45	0.689	0.744	0.814	0.948	0.946	0.850	0.0064	0.0082	0.0148	0.0036	0.0567	0.0748
11:45 - 12:15	0.650	0.642	0.579	0.673	0.841	0.936	0.0051	0.0063	0.0129	0.0322	0.0571	0.0748
12:15 - 12:45	0.786	0.743	0.740	0.862	0.923	0.893	0.0076	0.0114	0.0220	0.0283	0.0420	0.0760
12:45 - 13:15	0.766	0.865	0.874	1.009	0.933	0.872	0.0059	0.0100	0.0169	0.0327	0.0471	0.0722

A.13 Half hourly values of triple moments, $\overline{w'E}$, $\overline{w'T'^2}$ and $\overline{w'^2T'}$ at 6 levels during Run 1207

	$\overline{w'E}$ (x10^{-3}m^3/s^3)						$\overline{w'T'^2}$ (x10^{-3}m/s·°C^2)						$\overline{w'^2T'}$ (x10^{-3}m^2/s^2°C)					
TIME	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
7:45 - 8:15	0.42	4.26	0.13	-1.47	1.03	0.34	-0.288	0.253	-0.10T	0.266	0.163	0.234	-0.91	0.58	0.16	4.09	-0.20	-0.39
8:15 - 8:45	-1.76	-10.20	0.92	2.40	7.53	1.12	-0.078	-1.15	1.89	-6.24	2.18	0.465	1.48	3.95	0.21	2.61	-1.17	-0.00
8:45 - 9:15	-27.30	-5.45	0.26	-2.18	5.93	4.82	-2.51	3.14	5.40	-1.32	2.13	6.14	-5.47	-2.21	-21.2	-1.86	1.06	4.74
9:15 - 9:45	-6.62	4.44	7.02	22.3	28.1	14.3	-0.062	0.577	-0.171	4.97	10.9	12.6	-1.21	-3.48	-0.89	8.05	17.8	15.8
9:45 - 10:15	8.97	42.2	38.2	43.6	71.0	18.5	3.07	-2.49	3.00	11.3	21.8	25.4	-6.02	-9.52	12.7	20.0	38.9	18.8
10:15 - 10:45	14.9	27.5	37.4	116.	136.	24.2	2.07	2.72	5.75	14.1	29.9	22.3	12.7	9.9	15.8	29.5	61.8	12.9
10:45 - 11:15	107.	88.9	173.	213.	122.	37.4	4.12	5.75	12.4	22.3	32.6	35.7	13.3	17.8	42.1	56.5	61.4	37.8
11:15 - 11:45	123.	138.	97.2	123.	22.4	-1.57	3.61	6.81	9.00	28.1	18.6	19.1	11.5	28.5	22.5	62.6	35.1	16.7
11:45 - 12:15	99.4	144.	111.	103 .	52.8	23.6	6.42	9.58	12.1	28.2	49.5	36.0	40.5	48.8	43.9	35.3	69.4	39.5
12:15 - 12:45	160.	126.	139.	115.	62.3	32.7	3.81	8.44	17.8	10.3	20.3	47.8	16.3	27.5	44.3	21.1	48.7	43.8
12:45 - 13:15	130.	193.	148.	163.	50.2	-4.84	5.16	8.81	11.8	18.8	19.0	22.1	22.5	25.7	25.1	36.7	24.9	12.2

A.14 Half hourly values of dissipation rates of wind speed, ε and temperature, N_θ at 6 levels during Run 1207

	ε (x10⁻³ m²/s³)						Nθ (x10⁻³ ℃²/s)					
TIME	200m	150m	100m	50m	25m	10m	200m	150m	100m	50m	25m	10m
7:45 - 8:15	0.186	0.797	0.542	0.531	0.211	0.355	0.0022	0.0074	0.0031	0.0421	0.0065	0.0049
8:15 - 8:45	0.398	0.587	0.487	0.938	0.574	0.674	0.0030	0.0096	0.0187	0.0734	0.0321	0.0273
8:45 - 9:15	0.316	0.684	0.379	0.669	0.903	0.911	0.0102	0.0061	0.0085	0.0203	0.0173	0.0325
9:15 - 9:45	0.106	0.291	0.863	1.15	1.10	2.08	0.0010	0.0029	0.0056	0.0084	0.0207	0.0690
9:45 - 10:15	1.70	2.32	2.49	4.40	5.42	5.60	0.0110	0.0108	0.0099	0.0304	0.0761	0.1212
10:15 - 10:45	3.56	3.83	3.67	5.00	8.96	11.2	0.0033	0.0072	0.0095	0.0293	0.1013	0.2703
10:45 - 11:15	2.17	2.84	2.92	6.38	10.9	13.8	0.0051	0.0074	0.0137	0.0424	0.1283	0.2669
11:15 - 11:45	3.09	2.94	4.28	7.00	11.0	13.7	0.0052	0.0070	0.0222	0.0550	0.1440	0.3153
11:45 - 12:15	1.93	2.33	2.36	4.36	10.3	14.1	0.0026	0.0037	0.0075	0.0235	0.0960	0.2377
12:15 - 12:45	2.23	3.36	2.84	5.34	10.9	13.9	0.0049	0.0113	0.0132	0.0406	0.1357	0.2871
12:45 - 13:15	2.26	2.49	1.99	4.98	8.99	6.41	0.0053	0.0107	0.0168	0.0569	0.1027	0.2017

A.15 Half hourly values of mean wind speed, potential temperature specific humidity and turbulent fluxes, $\overline{w'T'}$ and $\overline{w'q'}$ at 3 levels during Run 281–Run 322

DATE	TIME	WIND SPEED(m/s)			POT TEMP(℃)			SPEC HUM(g/kg)			w'T' (m/s℃)			w'q' (m/s g/kg)			Run No.
		100m	50m	25m	100m	50m	25m	100m	50m	25m	100m	50m	25m	100m	50m	25m	
28 Oct	14:02-14:36	4.26	4.23	3.19	16.7	16.7	17.0	7.19	7.10	7.06	0.0127	———	0.0129	0.0194	0.0198	0.0207	Run 281
	14:36-15:10	3.92	4.03	2.81	16.7	16.9	16.9	7.12	7.02	6.99	-0.0002	———	0.0011	0.0045	0.0082	0.0152	〃
	15:40-16:14	4.76	4.16	2.93	——	15.9	15.9	——	7.34	7.38	-0.0025	-0.0046	-0.0078	0.0057	0.0070	0.0114	Run 282
	16:14-16:48	5.18	4.31	2.88	15.7	15.6	15.4	7.12	7.17	7.25	-0.0022	-0.0045	-0.0102	0.0028	0.0027	0.0048	〃
	17:10-17:44	5.09	3.93	2.57	15.6	15.2	14.9	7.09	7.29	7.48	0.0010	———	-0.0018	-0.0001	0.0015	0.0010	Run 283
	17:44-18:18	4.49	3.88	2.96	15.4	15.1	14.6	7.27	7.29	7.35	-0.0008	0.0000	-0.0009	0.0006	0.0002	0.0003	〃
30 Oct	14:40-15:14	1.62	0.91	1.61	13.2	13.4	13.5	3.29	3.18	3.16	0.0369	0.0216	0.0155	0.0036	0.0014	0.0108	Run 301
	15:14-15:48	2.45	2.78	1.98	13.3	13.4	13.5	3.21	3.14	3.14	0.0103	0.0052	0.0058	0.0082	0.0166	0.0141	〃
	16:15-16:49	4.75	5.17	2.82	12.9	12.8	12.6	3.60	3.59	3.66	-0.0038	-0.0070	-0.0209	0.0037	0.0033	0.0079	Run 302
	16:49-17:23	5.54	4.76	2.93	12.2	11.9	11.8	3.42	3.49	3.55	-0.0071	-0.0115	-0.0170	0.0073	0.0084	0.0074	〃
1 Nov	12:50-13:24	3.65	3.61	2.83	14.0	16.8	16.8	5.13	6.11	6.15	0.1030	0.0835	0.0841	0.0467	0.0450	0.0374	Run 321
	13:24-13:58	4.51	4.62	3.71	12.3	16.4	16.3	4.57	6.49	6.62	0.0541	0.0501	0.0568	0.0219	0.0231	0.0220	〃
	15:40-16:14	5.49	4.98	3.75	14.5	14.7	14.6	6.43	6.40	7.06	0.0003	-0.0043	-0.0053	0.0097	0.0086	0.0106	Run 322
	16:14-16:48	4.80	4.08	2.83	14.2	14.2	13.8	6.44	6.42	6.12	-0.0037	-0.0066	-0.0127	0.0031	0.0029	0.0056	〃

A.16 Half hourly values of Reynolds stress, $\overline{u'w'}$ and variance of vertival velocity, $\overline{w'^2}$ at 3 levels during Run 281–Run 322

		u'w' (m/s)²			w'² (m/s)²		
		100m	50m	25m	100m	50m	25m
28 Oct	14:02-14:36	-0.0298	-0.0563	-0.1146	0.2683	0.2162	0.2560
	14:36-15:10	-0.0245	-0.0271	-0.0912	0.1339	0.1376	0.1600
	15:40-16:14	-0.0128	-0.0429	-0.0946	0.0817	0.1096	0.1576
	16:14-16:48	-0.0059	-0.0114	-0.0382	0.0320	0.0538	0.0806
	17:10-17:44	-0.0019	-0.0054	-0.0057	0.0110	0.0114	0.0100
	17:44-18:18	-0.0015	-0.0013	-0.0028	0.0249	0.0081	0.0123
30 Oct	14:40-15:14	-0.1630	-0.0066	-0.0035	0.3237	0.1697	0.1204
	15:14-15:48	-0.0189	0.0148	-0.0480	0.2371	0.1466	0.1160
	16:15-16:49	-0.0291	-0.0911	-0.0674	0.1204	0.1211	0.1406
	16:49-17:23	-0.0448	-0.1430	-0.0597	0.1056	0.1536	0.1747
1 Nov	12:50-13:24	-0.0915	-0.1320	-0.1750	0.6099	0.4369	0.3552
	13:24-13:58	0.0696	0.0220	-0.1270	0.4057	0.3422	0.3295
	15:40-16:14	-0.0617	-0.0651	-0.1330	0.1640	0.1971	0.2480
	16:14-16:48	-0.0246	-0.0301	-0.0470	0.0841	0.0789	0.1036

A.17 Half hourly values of turbulent kinetic energy, E, temperature variance, $1/2\overline{T'^2}$ humidity variance, $1/2\overline{q'^2}$ and covariance, $\overline{T'q'}$ at 3 levels during Run 281–Run 322

		E $(m/s)^2$			$\frac{1}{2}\overline{T'^2}$ $(°C)^2$			$\frac{1}{2}\overline{q'^2}$ $(g/kg)^2$			$\overline{T'q'}$ (°C g/kg)		
DATE	TIME	100m	50m	25m	100m	50m	25m	100m	50m	25m	100m	50m	25m
28 Oct	14:02-14:36	0.552	0.978	0.740	0.0064	——	0.0078	0.0035	0.0051	0.0063	0.0047	——	0.0051
	14:36-15:10	0.356	1.500	0.533	0.0012	——	0.0011	0.0020	0.0028	0.0040	0.0008	——	0.0013
	15:40-16:14	0.205	0.361	0.472	0.0018	0.0011	0.0013	0.0023	0.0039	0.0024	-0.0027	-0.0020	-0.0025
	16:14-16:48	0.078	0.143	0.213	0.0011	0.0023	0.0043	0.0016	0.0010	0.0011	-0.0020	-0.0025	-0.0039
	17:10-17:44	0.036	0.329	0.059	0.0020	——	0.0033	0.0019	0.0015	0.0010	-0.0029	——	-0.0011
	17:44-18:18	0.079	0.084	0.061	0.0055	0.0067	0.0055	0.0042	0.0021	0.0007	-0.0088	0.0007	-0.0028
30 Oct	14:40-15:14	0.592	1.130	0.527	0.0068	0.0066	0.0078	0.0018	0.0026	0.0034	0.0016	0.0078	0.0102
	15:14-15:48	0.441	0.355	0.369	0.0010	0.0010	0.0013	0.0007	0.0042	0.0065	0.0012	0.0024	0.0038
	16:15-16:49	0.420	0.865	0.422	0.0019	0.0034	0.0101	0.0030	0.0026	0.0032	-0.0008	-0.0032	-0.0092
	16:49-17:23	0.259	0.893	0.441	0.0042	0.0037	0.0085	0.0034	0.0023	0.0025	-0.0066	-0.0049	-0.0081
1, Nov	12:50-13:24	1.029	1.159	1.210	0.0206	0.0300	0.0395	0.0057	0.0098	0.0125	0.0153	0.0270	0.0369
	13:24-13:58	0.842	1.060	1.149	0.0117	0.0131	0.0196	0.0051	0.0053	0.0066	0.0077	0.0090	0.0136
	15:40-16:14	0.384	0.527	0.649	0.0004	0.0008	0.0008	0.0022	0.0018	0.0019	-0.0000	-0.0010	-0.0012
	16:14-16:48	0.194	0.244	0.314	0.0008	0.0021	0.0057	0.0010	0.0008	0.0012	-0.0011	-0.0018	-0.0042

A.18 Half hourly values of triple moments, $\overline{w'E}$, $\overline{w'T'^2}$, $\overline{w'q'^2}$, $\overline{w'^2T}$, and $\overline{w'^2q'}$ at 3 levels during Run 281–Run 322

DATE	TIME	$\overline{w'E}$ $(\times10^{-3} m^3/s^3)$			$\overline{w'T'^2}$ $(\times10^{-3} m/s°C^2)$			$\overline{w'q'^2}$ $(\times10^{-3} m/s g/kg^2)$			$\overline{w'^2T'}$ $(\times10^{-3} m^2/s^2 °C)$			$\overline{w'^2q'}$ $(\times10^{-3} m^2/s^2 g/kg)$		
		100m	50m	25m	100m	50m	25m	100m	50m	25m	100m	50m	25m	100m	50m	25m
28 Oct	14:02-14:36	30.6	64.6	7.3	1.19	——	0.22	0.57	0.15	-0.13	5.75	——	0.39	2.76	5.18	4.93
	14:36-15:10	17.7	-8.5	29.7	0.02	——	0.23	0.34	0.30	0.41	0.70	——	1.13	1.68	1.98	3.72
	15:40-16:14	3.6	21.1	23.8	0.12	0.05	0.00	0.38	0.23	-0.03	-2.82	-0.50	-1.48	3.77	1.54	1.97
	16:14-16:48	0.2	4.9	10.1	0.05	0.14	0.41	0.01	0.03	0.13	-0.19	-0.54	-1.08	0.36	0.23	0.46
	17:10-17:44	0.0	0.8	-0.1	0.01	——	0.16	0.07	0.01	-0.01	-0.17	——	-0.36	0.17	0.01	-0.01
	17:44-18:18	0.8	0.0	0.6	0.10	-0.03	0.13	0.00	0.00	0.00	0.54	0.07	-0.39	-0.34	-0.07	0.03
30 Oct	14:40-15:14	12.7	99.8	32.6	1.05	1.55	2.24	-0.95	0.65	1.14	-0.25	2.14	3.81	1.84	0.74	2.58
	15:14-15:48	51.4	11.3	27.3	0.27	0.17	0.18	0.51	2.21	1.13	2.08	1.25	1.52	3.38	6.82	4.19
	16:15-16:49	-7.3	1.8	7.0	0.11	0.29	0.03	-0.30	-0.28	-0.12	-0.75	-0.16	-0.61	-0.01	-1.22	-1.08
	16:49-17:23	18.2	34.5	7.9	0.02	0.62	0.09	0.08	-0.01	-0.05	-1.69	-0.25	-2.51	2.47	0.55	0.90
1 Nov	12:50-13:24	188.0	162.9	57.6	7.69	4.64	10.69	2.81	1.98	1.08	19.39	21.59	17.50	11.79	10.60	9.28
	13:24-13:58	67.4	115.0	109.0	9.04	3.64	6.08	0.23	-0.39	0.02	22.69	16.59	25.39	4.00	3.91	12.09
	15:40-16:14	64.9	13.0	31.2	0.12	0.20	-0.17	-0.18	-0.09	-0.33	0.30	-0.54	-1.18	3.37	0.35	0.80
	16:14-16:48	6.2	-4.2	4.8	0.06	0.02	0.31	-0.01	-0.04	0.04	-0.35	0.44	-0.57	0.09	-0.22	0.40

A.19 Half hourly mean values of dissipation rates of wind speed, ε temperature, N_θ and humidity, N_q at 3 levels during Run 281–Run 322

		ε $(\times10^{-3} m^2/s^3)$			N_θ $(\times10^{-3} (°C)^2/s)$			N_q $(\times10^{-3} (g/kg)^2/s)$		
DATE	TIME	100m	50m	25m	100m	50m	25m	100m	50m	25m
28 Oct	14:02-14:36	0.4588	1.0866	1.9672	0.0068	——	0.0285	0.0058	0.0136	0.0325
	14:36-15:10	0.3271	0.5058	1.2178	0.0013	——	0.0041	0.0045	0.0072	0.0211
	15:40-16:14	0.2315	0.6930	1.5181	0.0029	0.0041	0.0116	0.0040	0.0276	0.0111
	16:14-16:48	0.0801	0.3542	1.0417	0.0024	0.0140	0.0405	0.0022	0.0043	0.0079
	17:10-17:44	0.0269	0.0502	0.1130	0.0030	——	0.0148	0.0018	0.0018	0.0011
	17:44-18:18	0.0876	0.0195	0.0929	0.0082	0.0032	0.0230	0.0068	0.0011	0.0010
30 Oct	14:40-15:14	0.4533	1.3971	0.5783	0.0087	0.0376	0.0272	0.0083	0.0158	0.0098
	15:14-15:48	0.1936	0.0714	0.5456	0.0023	0.0020	0.0056	0.0008	0.0060	0.0209
	16:15-16:49	0.2517	0.1870	1.1610	0.0026	0.0112	0.0840	0.0035	0.0049	0.0201
	16:49-17:23	0.5899	0.8764	2.3953	0.0149	0.0261	0.0958	0.0108	0.0110	0.0212
1 Nov	12:50-13:24	1.2878	1.3621	2.0608	0.0596	0.0977	0.1902	0.0094	0.0181	0.0449
	13:24-13:58	0.4342	1.0551	2.2538	0.0187	0.0578	0.1412	0.0046	0.0100	0.0205
	15:40-16:14	0.3961	0.9390	2.6146	0.0637	0.0019	0.0057	0.0042	0.0046	0.0118
	16:14-16:48	0.1936	0.5326	1.1165	0.0023	0.0125	0.0515	0.0019	0.0034	0.0068